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Improving public engagement with air pollution: exploring two-way communication formats, public perception, and the voices of women.

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A thesis submitted in partial fulfilment of the requirements of the Manchester Metropolitan University for the degree of **Doctor of Philosophy**

Manchester Metropolitan University
Faculty of Science and Engineering
School of Science and the Environment

September 2019

To my family, always

With thanks to

Many people in different countries have been key in shaping this thesis and in providing the most valuable professional advice and moral support. This thesis was created in conversations of many different natures that have taken place in meeting rooms, bars, the streets, at home, over the phone, or through social media. Thank you to each and every one of you who has taken the time to speak with me.

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Abstract

Cities worldwide are experiencing high levels of air pollution, with severe consequences to human health, the economy, and the natural environment. Greater Manchester (GM), a conurbation in the United Kingdom, has declared an Air Quality Management Area (AQMA) as air pollution levels are sometimes above or close to limits set by the European Union. Transport is one of the main contributing sectors, and rapid policy and lifestyle changes are needed when it comes to public transportation, walking, or cycling. Public engagement is central to this aim, but one-way provision of information is not effective in encouraging the needed behavioural changes. Through a systematic review (n=50), this thesis provides a comparison of how five different two-way communication formats (i.e. social media, educational programmes, serious games, citizen science, and forums) have been employed worldwide to create dialogues between experts and the public in relation to air pollution. A one-size-fits-all communication strategy is not sufficient in engaging the public in socially diverse cities where the environment and sustainable lifestyles are conceptualised in a myriad of ways. Through a questionnaire study (n=365), this thesis explores how the public in GM perceives air pollution and accesses environmental information, as well as how this varies with gender, educational level, age, postcode district, and income. Through qualitative interviews (n=30), this thesis also provides an in-depth exploration of the experiences of one particular group in society that has traditionally been underserved: women. The focus on women is necessary because a greater responsibility for unpaid work, economic inequality, longer life expectancy, and greater fear of crime shape how women travel and access the city, and consequently, their experiences of air pollution. The fact that these findings are specific to women, however, does not make them less valid in relation to society at large. A transportation system that is environmentally sustainable as well as safe, economical, and that facilitates combining paid and unpaid work, is beneficial to all. These findings advance knowledge in the field of public engagement with air pollution, and provide recommendations for policymakers or charity organizations. These include communication of air pollution as something physical, moving away from the invisible adjective that encourages people to avoid the problem altogether; and the further exploration of the health and well-being frame, as it can be effective in motivating active forms of transport.

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List of abbreviations

AGMA	Association of Greater Manchester Authorities
AQAP	Air Quality Action Plan
AQG	Air Quality Guidelines
AQMA	Air Quality Management Area
As	Arsenic
BAP	Benzo[*a*]pyrene
BME	Black and Minority Ethnics
C_6H_6	Benzene
Cd	Cadmium
CEDA	Centre for Environmental Data Analysis
CH_4	Methane
CO	Carbon monoxide
Defra	Department for Environment, Food and Rural Affairs
EU	European Union
GM	Greater Manchester
GDP	Gross Domestic Product
GMCA	Greater Manchester Combined Authorities
GMSF	Greater Manchester Spatial Framework
Hg	Mercury
IPCC	Intergovernmental Panel on Climate Change
LGBT	Lesbian, Gay, Bisexual, and Transgender
NDCs	Nationally Determined Contributions
NH_3	Ammonia
Ni	Nickel
NIMBY	Not in My Back Yard
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide
O_3	Ozone
Pb	Lead
PM	Particulate Matter
RQ	Research Question
SO_2	Sulphur dioxide
TfGM	Transport for Greater Manchester
UK	United Kingdom

UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VOC	Volatile organic compounds
WHO	World Health Organization
WWF	World Wide Fund for Nature

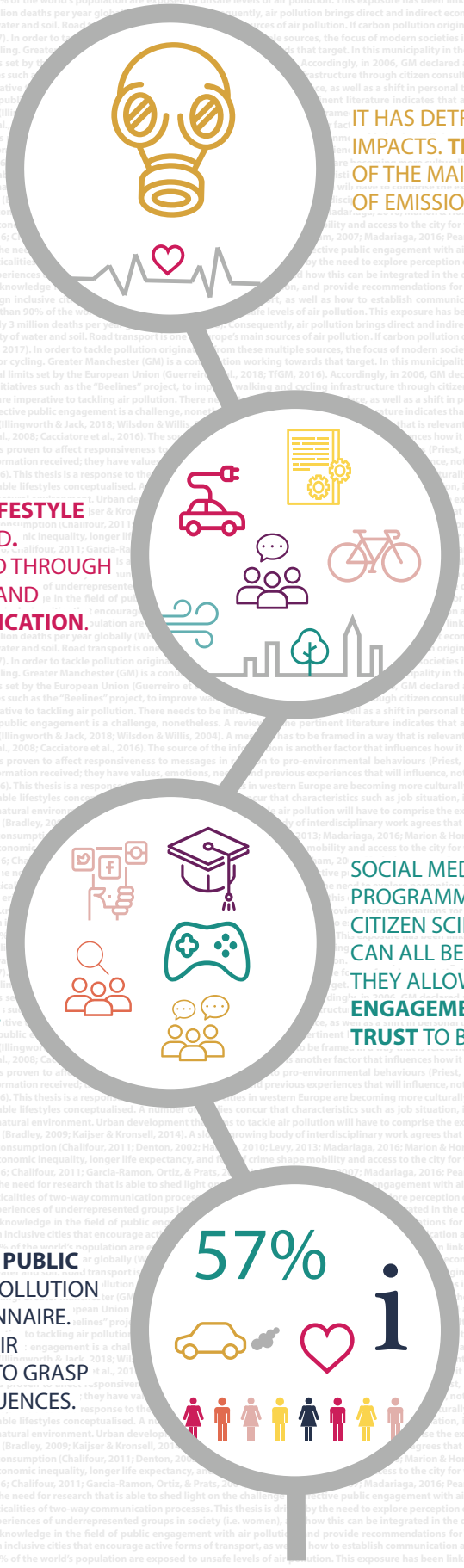
Thesis infographic

Air pollution, dialogues, public perception, and women

The word infographic is a portmanteau of 'information' and 'graphic'. An infographic is a visualization of an idea, which combines illustrations and typography, and in an era of information overload, infographics communicate information in a way that is visually appealing. They make information processing and retention easy and effortless (Lankow et al., 2012; Smiciklas, 2012).

I have represented this thesis with an infographic, because I want to make your job as a reader easier; because I want to be able to share this thesis with my participants without asking them for more time; because I want to share findings with the general public and a thesis is not a particularly accessible or inviting document. I have created an infographic because I enjoy visual communication and design. And ultimately, because I want to finish this three-year journey with a science communication challenge: condensing more than 200 pages into two.

The main chapters in this thesis (Chapters II, III, IV, and V) are also introduced with an infographic, a visual abstract if you like. These too are designed to make the reading more enjoyable, and the content more accessible and shareable.


90% OF THE WORLD POPULATION IS EXPOSED TO AIR POLLUTION.
IT HAS DETRIMENTAL HEALTH IMPACTS. TRANSPORT IS ONE OF THE MAIN SOURCE OF EMISSIONS.
RAPID POLICY AND LIFESTYLE CHANGES ARE NEEDED. THIS CAN BE ACHIEVED THROUGH RELEVANT POLICIES AND EFFECTIVE COMMUNICATION.
PUBLIC-EXPERT DIALOGUES AND EXPLORING PUBLIC PERCEPTION ARE KEY.
THIS THESIS EXPLORES DIFFERENT TWO-WAY COMMUNICATION POSSIBILITIES THROUGH A SYSTEMATIC REVIEW.
SOCIAL MEDIA, EDUCATIONAL PROGRAMMES, SERIOUS GAMES, CITIZEN SCIENCE, AND FORUMS CAN ALL BE EFFECTIVE. THEY ALLOW MEANINGFUL ENGAGEMENT AND TRUST TO BE FOSTERED.
THIS THESIS EXPLORES PUBLIC PERCEPTION OF AIR POLLUTION THROUGH A QUESTIONNAIRE. 57% ARE AWARE OF AIR POLLUTION, BUT FAIL TO GRASP THE HEALTH CONSEQUENCES.
57%
SCIENTISTS ARE HIGHLY TRUSTED. THE MEDIA IS THE PREFERRED SOURCE OF INFORMATION. GENDER IS KEY IN SHAPING PERCEPTION.

GENDER IS KEY. **UNPAID WORK**, **ECONOMIC INEQUALITY**, **LIFE EXPECTANCY**, AND **FEAR OF CRIME**, SHAPE WOMEN'S MOBILITY, ACCESS TO THE CITY, TIME SPENT OUTDOORS, AND EXPOSURE AND **EXPERIENCES OF AIR POLLUTION**.

THE **VOICES OF WOMEN** ARE KEY IN SHAPING THE **FUTURE** OF CLEAN AIR.

THIS THESIS EXPLORES THE VOICES OF WOMEN THROUGH **INTERVIEWS**. THEY TALK ABOUT AIR POLLUTION AS SOMETHING **PHYSICAL**: IT CAN BE TASTED OR SMELLED.

HEALTH AND WELLBEING ARE MOTIVATORS FOR ACTIVE FORMS OF TRANSPORT. **CRIME OR HOMELESSNESS** INFLUENCE THE EXPERIENCE OF THE OUTDOORS AND MOBILITY AND ARE CENTRAL TO AIR POLLUTION.

POLICIES IN RELATION TO AIR POLLUTION SHOULD CONCERN FACTORS THAT ARE **DIRECTLY** LINKED TO AIR POLLUTION, SUCH AS CYCLING INFRASTRUCTURE

AS WELL AS FACTORS THAT ARE **INDIRECTLY** LINKED TO AIR POLLUTION, SUCH AS CLEAN AND SAFE ENVIRONMENTS THAT ENCOURAGE WALKING.

AIR POLLUTION SHOULD BE **COMMUNICATED**

AS SOMETHING **PHYSICAL**, MOVING AWAY FROM THE INVISIBLE AND UNGRASPABLE ADJECTIVES. USING THE **HEALTH AND WELLBEING** FRAME. WITH **POSITIVE** MESSAGES. HIGHLIGHTING **PLEASANT URBAN ENVIRONMENTS** FOR PEOPLE.

THIS THESIS DEMONSTRATES THE IMPORTANCE OF ESTABLISHING DIALOGUES ABOUT HOW TO TACKLE AIR POLLUTION WITH GROUPS IN SOCIETY THAT HAVE TRADITIONALLY BEEN UNDERSERVED, SUCH AS WOMEN.

Icons from www.flaticon.com

Chapter I

Introduction

This thesis is written at a time when more than 90% of the world population is exposed to unsafe levels of air pollution (WHO, 2018). This exposure has been linked to numerous health problems (Kampa and Castanas, 2008; Lelieveld et al., 2015), and it is now thought to be responsible for approximately 3 million deaths per year globally (WHO, 2018). Consequently, air pollution brings direct and indirect economic impacts. Air pollution also poses a threat to fauna and flora, as well as the quality of water and soil, and road transport is one of Europe's main sources of air pollution. Whilst carbon pollution originates from car exhausts, Particulate Matter (PM) is also derived from tyre and break wear (Defra, 2017). In order to tackle pollution originating from these multiple sources, the focus of many modern societies is to move to electric cars, but importantly, also to active non-polluting forms of transport such as walking or cycling (TfGM, 2016a). Greater Manchester (GM) in the North West of England is a conurbation working towards that target. In this municipality many locations record air pollution levels above or close to annual limits set by the European Union (TfGM, 2016a; Guerreiro et al., 2018). In 2006, GM declared a single AQMA (Air Quality Management Area) (TfGM, 2016a). The city is now investing in initiatives such as the 'Beelines' project, to improve walking and cycling infrastructure through citizen consultation efforts (TfGM, 2018).

The research embodied in this thesis has emerged at a time when the need for rapid policy and lifestyle changes are imperative in order to tackle air pollution. There needs to be new infrastructure in place, as well as a shift in personal travel choices. Both of these important areas of action require public engagement, but effective public engagement can present a significant challenge, nonetheless. A review of the pertinent literature indicates that a dialogical approach can, in principle, be more effective than a one-way provision of information (Wilsdon and Willis, 2004a; Illingworth and Jack, 2018). To be received and comprehended, a message has to be framed in a way that is relevant to an individual's pre-existing knowledge and understanding (Bickerstaff, 2004; Burningham et al., 2008; Cacciatore et al., 2016). The source of the information is another factor that influences how a message is perceived and assessed, and lack of trust in a source, such as the government or the media, has proven to affect responsiveness to messages in relation to pro-environmental behaviours (Priest, 2016). Individuals

are not passive receivers of information, ready to absorb and act upon the information received; they have values, emotions, needs, and previous experiences that will influence, not only the way the information is processed, but also their consequent behaviour (Longnecker, 2016).

This thesis is also a response to the fact that many cities in western Europe are becoming more culturally and socially diverse, accentuating differences in how the environment is perceived and sustainable lifestyles conceptualised (Bradley, 2009; Kaijser and Kronsell, 2014). A number of studies concur that characteristics such as job situation, income, gender, ethnicity, or age are central in shaping people's needs and their experiences of the urban and natural environment (Bradley, 2009; Kaijser and Kronsell, 2014). A slowly growing body of interdisciplinary work agrees that gender is central in dealing with emissions and climate change, sustainable mobility, and energy consumption (Denton, 2002; Marion and Horner, 2007a; Polk, 2009; Hanson, 2010; Chalifour, 2011; Levy, 2013; Madariaga, 2016b). Studies agree that a gender approach is key because unpaid work, economic inequality, longer life expectancy, and fear of crime shape mobility and access to the city for women, and consequently their experiences of air pollution (Root et al., 2000; Garcia-Ramon et al., 2004; Johnsson-Latham, 2007; Polk, 2009; Chalifour, 2011; Buckingham, 2016; Madariaga, 2016b; Beebeejaun, 2017; Pearse, 2017; Buckingham, 2018; Alber, 2018). For example, economic inequality is translated into a greater reliance on public transport and less mobility, tying women to the local environment, increasing the time they spend outdoors (Polk, 2009; Buckingham, 2018), and affecting their exposure to air pollution.

In this context, the study contained in this thesis is a response to the need for research that is able to shed light on the challenge of effective public engagement with air pollution. This work is motivated by the need for studies that investigate the potential and practicalities of two-way communication processes. It is driven by the need to explore the perception of air pollution by different societal groups, and in particular to provide an in-depth analysis of the needs and experiences of underrepresented groups in society (specifically women), and explore how these 'voices' can be integrated in the dialogue and development of future cities in tackling air pollution.

The aim of this research is to advance knowledge in the field of public engagement with air pollution, and provide recommendations for policymakers or charity organizations. These recommendations, arising from an in-depth exploration of the voices of women, would guide how to best design inclusive cities that encourage active forms of transport, as well as how to establish communication that is able to change behaviours and lifestyle choices.

1.1 Research questions

This thesis will address the following three research questions:

Research Question One (RQ1): what two-way communication formats can be used for establishing dialogues between experts (with scientific knowledge) and the public (with experiential knowledge)[1] in relation to air pollution, and how?

Research Question Two (RQ2): how does the public in Greater Manchester perceive air pollution and access related information, and what factors affect perception and information consumption habits?

Research Questions Three (RQ3): how do women in Greater Manchester conceptualize air pollution and envision a city with clean air?

[1] In this thesis the distinction between experts and the public does not represent a distinction between 'knowledge' or 'expertise' and lack thereof. This is why the term 'non-experts', often used to refer to the public (e.g. Whitmarsh et al., 2009), has been avoided. This thesis understands that the public possesses very valuable "experiential, placed-based, and non-scientific knowledge" (Rice et al., 2015:254); that they have personal interest in the problems to be solved (Miller, 2001); and that this highly pertinent knowledge and interest make them instrumental in driving local solutions (Burningham et al., 2008).

1.2 Methodological considerations

This thesis combines quantitative and qualitative approaches to data collection, analysis, and reporting. Both these approaches, however, assume that reality is constructed between people and in relation to one another (social constructionism), that human beings act on the basis of how they interpret reality, and that the way a researcher can access that reality is by providing an interpretation of the subjective meaning of social action (interpretivism) (Guba and Lincoln, 1994; Burr, 2003; Bryman, 2012). This combination of research approaches does not take place at a paradigmatic level (i.e. combining questions of ontology and epistemology that can be fundamentally different in qualitative and quantitative research designs), but at a technical one (i.e. combining technicalities and affordances of these research methods, such as breadth and depth). The methods employed in this thesis are: a systematic review (in relation to RQ1), a questionnaire (in relation to RQ2), and in-depth interviews (in relation to RQ3). An in-depth explanation of the methodologies and perspectives on data is provided in Chapter IV (Section 4.2.1) and Chapter V (Section 5.2.1).

1.3 Thesis structure

This thesis is structured as follows:

Chapter II presents an in-depth background to the project by examining the existing literature concerning the interests of this thesis. It focuses on the challenges of air pollution, public engagement, and gender.

Chapter III relates to the first research question (RQ1), and describes results from a systematic review of fifty studies exploring how two-way communication can be established between experts (with scientific knowledge) and the public (with experiential knowledge) in relation to air pollution.

Chapter IV relates to the second research question (RQ2) and describes results from a questionnaire with a representative sample of 365 respondents in GM. It

explores public perception of environmental hazards and information consumption habits. In this chapter, relationships are investigated with factors that have been shown to influence perception: education, age, income, postcode district, and gender.

Chapter V relates to the third research question (RQ3) and describes results from 30 qualitative interviews with women in GM. It explores how women experience air pollution and imagine an urban environment with clean air.

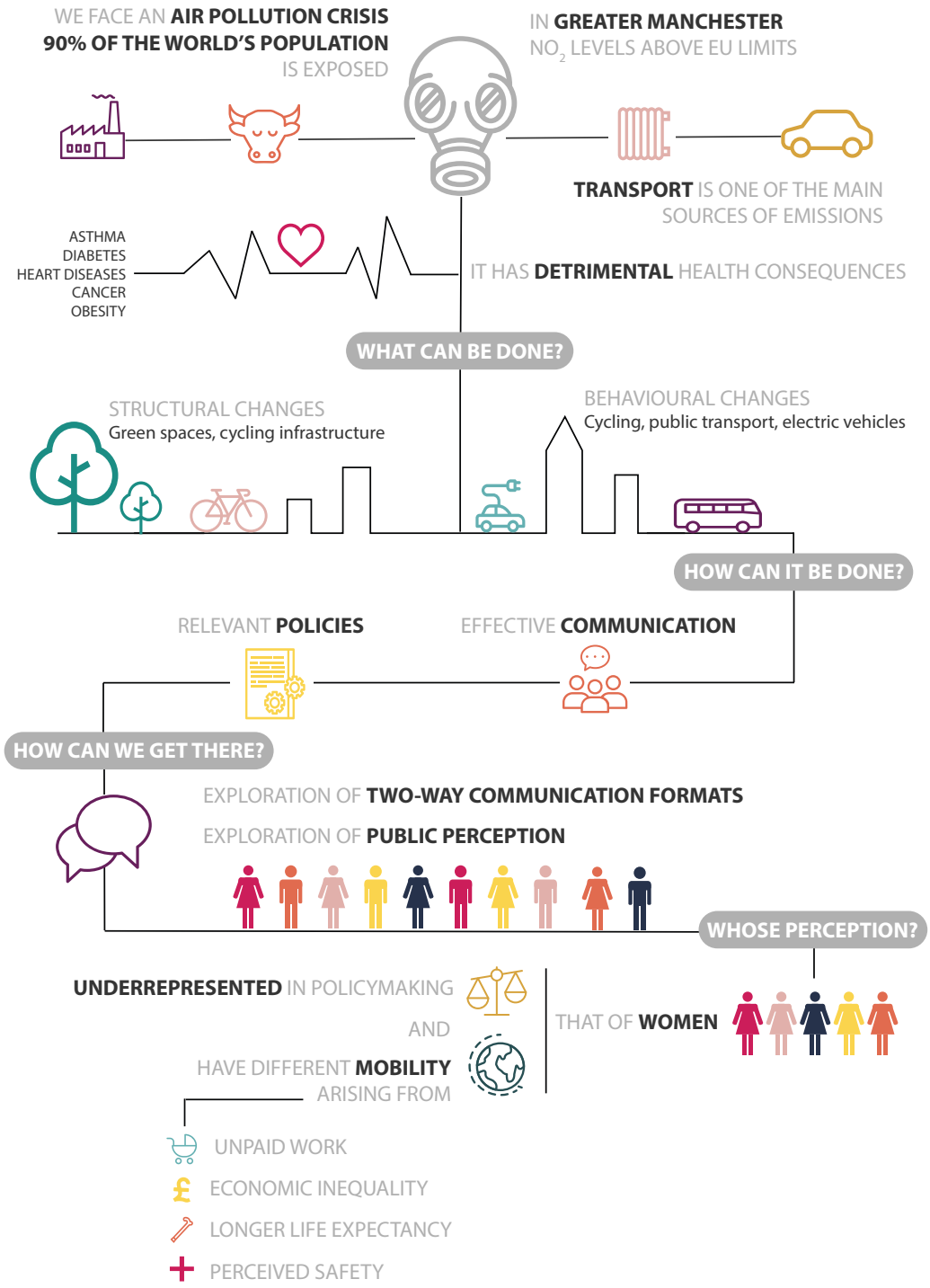
Chapter VI is about synthesis and reflection. It highlights the interconnections between the different parts of this research. It considers the implications of this study and outlines a series of recommendations for effective public engagement with air pollution. This chapter also outlines different avenues for future research.

Chapter II

Air pollution, public engagement and gender challenges

Infographic

The future of air pollution is female



Overview

This chapter introduces and defines three key 'challenges', and as such, lays out a synthesis of existing findings that constitutes an original contribution to knowledge (Figure 2.1). It concludes by identifying current knowledge gaps. Firstly, this chapter introduces the air pollution challenge (Section 2.1) in Europe, the United Kingdom (UK) and Greater Manchester (GM). This environmental challenge explains that 90% of the world population breathes polluted air, and that GM declared a single AQMA (Air Quality Management Area) in 2006 as many locations in the city record air pollution levels above or close to annual limits set by the European Union (EU). Transport is one of the main sources of air pollution and a transformation towards cleaner air involves electric transport as well as active forms of transport (i.e. walking or cycling). Secondly, this chapter also introduces the public engagement challenge (Section 2.2)[2]. This challenge surrounding public engagement discusses how public acceptance and engagement are key in the rapid policy and lifestyle changes needed to tackle air pollution, but that the public are generally disengaged and not taking sufficient action. This chapter explores reasons for public disengagement, such as how air pollution is a 'wicked' problem, i.e. complex and difficult to solve (Lazarus, 2009), as it is difficult to grasp and prioritize, and has not been communicated effectively. It highlights the lack of examination of formats that can facilitate dialogue between all the stakeholders involved, drawing attention to the lack of consideration given to the values, emotions, needs, and experiences of different individuals in society, as well as the environment within which they are embedded. Finally, and thirdly, this chapter introduces the gender challenge (Section 2.3). The challenge associated with gender emphasizes the need for social studies exploring public perception, especially of those groups in society that have traditionally been

[2] The public engagement challenge (Section 2.2) in this chapter has been published as the following paper and can be found in Appendix 2.1:
Loroño-Leturiondo, M., O'Hare, P., Cook, S., Hoon, S. R. & Illingworth, S. (2018). Give me five! – reasons for two-way communication between experts and citizens in relation to air pollution risk. *Adv. Sci. Res.* **15,** 45–50

underrepresented (i.e. women) and who have different needs to those which have been established as the norm.

Figure 2.1 offers an overview of the key concepts in this chapter and the three challenges presented above. This thesis lies at the centre of air pollution studies and science communication (RQ1: what two-way communication formats can be used for establishing dialogues between experts (with scientific knowledge) and the public (with experiential knowledge) in relation to air pollution, and how? and RQ2: how does the public in Greater Manchester perceive air pollution and access-related information, and what factors affect perception and information consumption habits?) and women's studies (RQ3: how do women in Greater Manchester conceptualize air pollution and envision a city with clean air?).

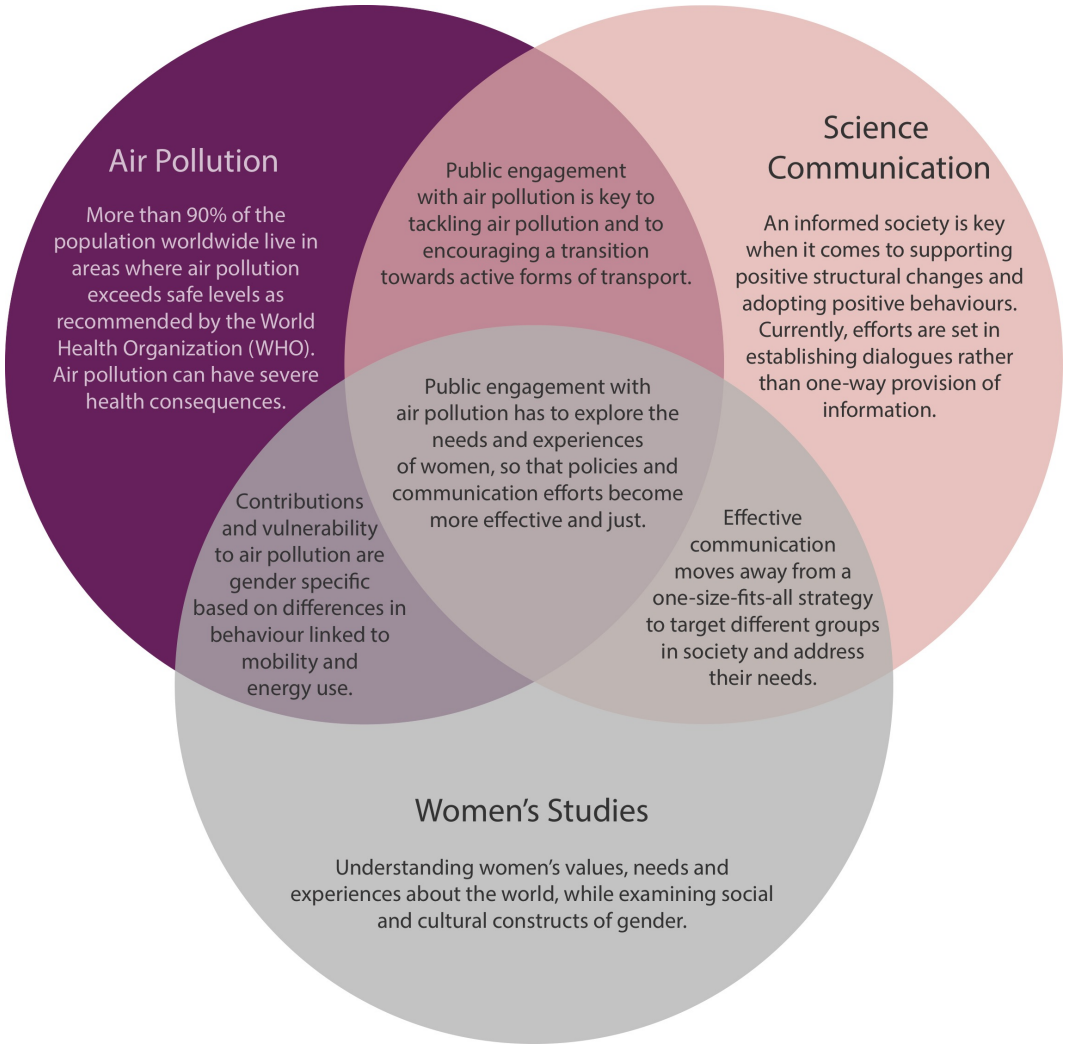


Figure 2.1 The three areas of study involved in this thesis, outlining how they relate to one another and the thesis in general.

2.1 The air pollution challenge

Human activity is responsible for approximately 1°C of global warming above pre-industrial levels (i.e. 1850- 1900) (IPCC, 2018). At the present rate, the world is on course for 3°C of warming before the year 2100, which would magnify the already visible consequences of global warming (IPCC, 2018). These consequences, which at first were largely environmental (such as ocean acidification or loss of biodiversity), are now directly threatening the health and life of humans. Extreme environmental changes, such as droughts, are forcing millions of people out of their homes and countries, as access to food and clean water becomes scarcer (FOE, 2018; IPCC, 2018; UNHCR, 2018). With the Paris Agreement on climate change, the international community has agreed to work towards limiting warming to 1.5°C. This commitment involves cutting carbon pollution by 45% by 2030 and becoming carbon neutral by 2050 – which under the alternative 2°C pathway would have involved a 20% cut by 2030 and becoming carbon neutral by 2075 (IPCC, 2018). To meet this ambitious target, action is needed in sectors such as transport, the built environment, and agriculture (Clarke et al., 2018; IPCC, 2018). Road transport is one of Europe's main sources of emissions (Guerreiro et al., 2018), and cities are working towards a carbon neutral transport fleet by adopting measures such as increasing the number of electric vehicle charging points or introducing low-emission buses (TfGM, 2016b).

Carbon pollution, however, is not the only pollutant of concern. Ambient air pollution, which includes carbon as well as a series of other pollutants, such as Particulate Matter (PM) or Nitrogen dioxide (NO_2) (Figure 2.2), is posing severe health problems worldwide. According to the World Health Organization (WHO), more than 90% of the world population lives in places that exceed safe air pollution levels. In Europe (EU-28) alone, between 2014 and 2016 the urban population exposed to levels above those recommended by WHO reached a maximum of 85% (for the case of $PM_{2.5}$) (Guerreiro et al., 2018). This level of exposure has been linked to cancer, asthma, stroke, heart disease, diabetes, obesity, and dementia, and it is now thought to be responsible for approximately 3 million deaths per year globally (Kampa and Castanas, 2008; WHO, 2013;

Lelieveld et al., 2015). Consequently, air pollution brings direct and indirect economic impacts, due to additional healthcare costs and reduced productivity through working days lost due to illness. Furthermore, air pollution also poses a threat to the natural environment as it affects vegetation and fauna, as well as the quality of water and soil.

Pollutants such as PM, for instance, can have more directly harmful consequences for human health than carbon. These particles (of $PM_{2.5}$ specifically – 2.5 micrometres or less in diameter; but also PM_{10} – 10 micrometres or less in diameter), are small enough to be inhaled into the airways of the lungs increasing the likelihood of developing cancer as well as respiratory and cardiovascular problems (Kampa and Castanas, 2008; Lelieveld et al., 2015; Brugge, 2018). As with carbon, PM is also linked to the transport sector as its main sources are emissions from exhausts as well as tyre and break wear (Figure 2.2) (Defra, 2017). This means that although moving to electric cars would improve emissions from exhausts, it would still be contributing to air pollution more broadly. Consequently, the focus of modern societies should not only set on changing to electric vehicles, but importantly, to active forms of transport, such as walking or cycling, that would effectively meet both the 1.5°C target and the air pollution agenda and objectives (Clarke et al., 2018).

2.1.1 Air pollution in Europe

The European Union (EU) is working on understanding, measuring, and mitigating a number of air pollutants (Figure 2.2). These are: particulate matter (PM), volatile organic compounds (VOC), nitrous oxides (NO_x), carbon monoxide (CO), benzene (C_6H_6), methane (CH_4), benzo[*a*]pyrene (BAP), sulphur dioxide (SO_2), arsenic (As), mercury (Hg), lead (Pb), cadmium (Cd), nickel (Ni), ammonia (NH_3), and ozone (O_3). As can be seen in Figure 2.2, these pollutants originate from various sources often simultaneously; namely transport, industry, electricity and heat production, agriculture, waste disposal, fires, and from chemical reactions in the air. These air pollutants can have severe health and environmental consequences. They elevate the risk of respiratory and cardiovascular problems, cancer, headaches, anxiety,

and birth defects, as well as causing irritation of the skin, eyes, and throat. They also contribute to a warming of the Earth, acidification of soil, rivers and lakes, reduced growth of crops, damage to the health of animals, and other consequences such as damage to buildings and cultural heritage (Defra, 2017; EEA, 2017). These health and environmental consequences are in turn translated into indirect economic losses.

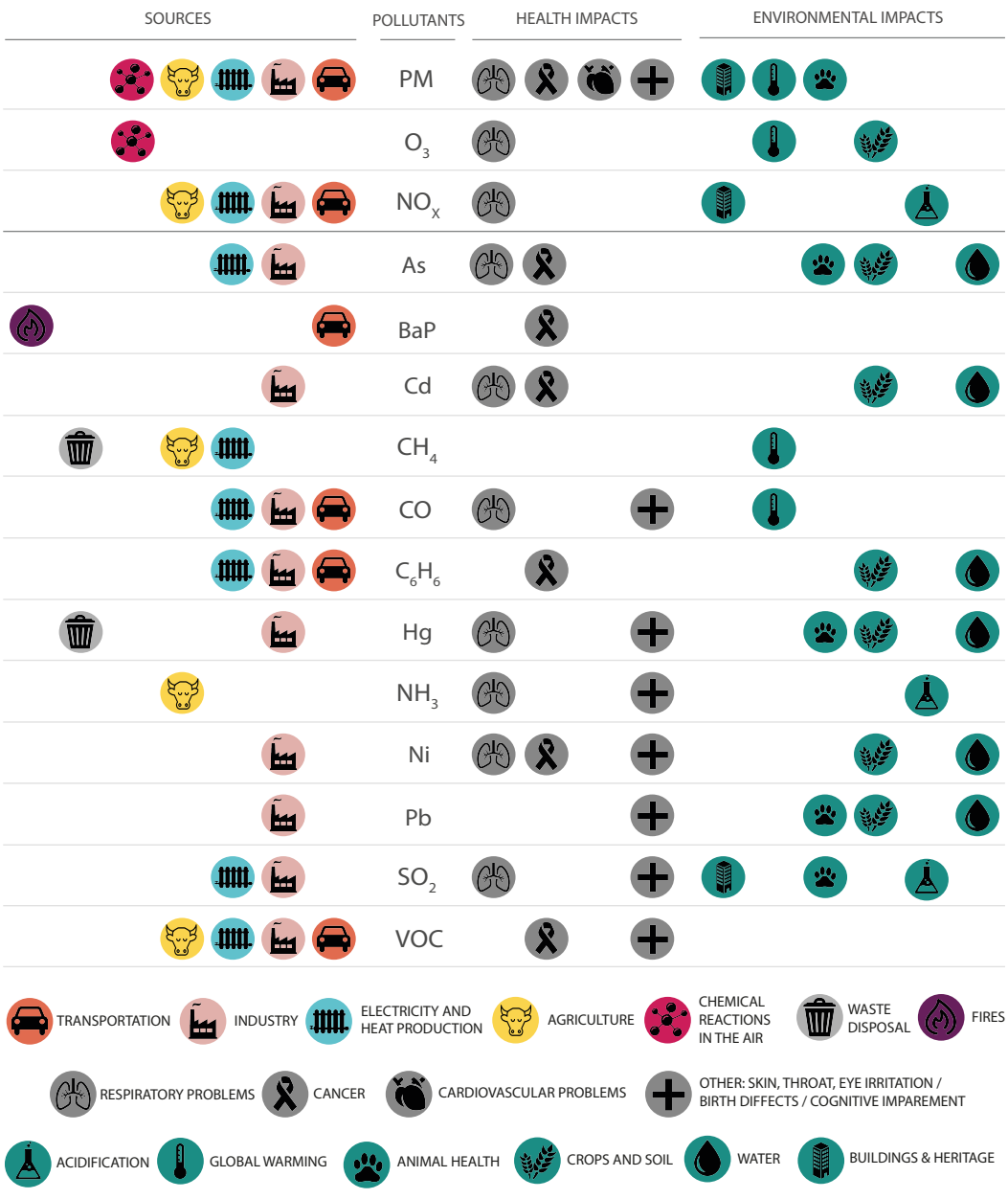


Figure 2.2 Pollutants in the European Union (EU), the sources of these pollutants, and their health and environmental impacts. The three pollutants that are monitored to a greater extent have been placed at the top of the chart. The others appear in alphabetical order. Source: Defra, 2017; EEA, 2017; Guerreiro et al., 2018.

In relation to air pollution legislation in the EU, the Cleaner Air for Europe Directive 2008/50/EC came into force in 2008, merging the existing legislation on ambient air quality for pollutants such as PM_{10} and $PM_{2.5}$ and NO_2. This directive coexists with the Fourth Daughter Directive (Directive 2004/107/EC) that regulates other pollutants such as toxic metals or organic compounds. These two directives set legally binding limits and a number of exceedances allowed per year for individual pollutants, known as 'limit values' (Defra, 2017). These Directives also gather 'target values' for countries to meet in the short term as well as more ambitious 'long-term objectives' (Defra, 2017). Additionally, for the specific case of carbon emissions responsible for global warming, the Paris Agreement (2015) works on the basis of Nationally Determined Contributions (NDCs), taking into account the individual country's domestic circumstances and capabilities that are to be revised, reported, and strengthened in the years ahead (UNFCCC, 2018).

At the EU level, there are three pollutants that are being measured to a greater extent as they have been found to have the most severe health impacts. These are: PM (2.5 and 10), O_3, and NO_2. Figure 2.3 shows air quality standards as given by the EU Ambient Air Quality Directive and WHO, and the percentage of the European population living in places exceeding these levels. The WHO values for the protection of health are stricter than those politically agreed by the EU (Guerreiro et al., 2018).

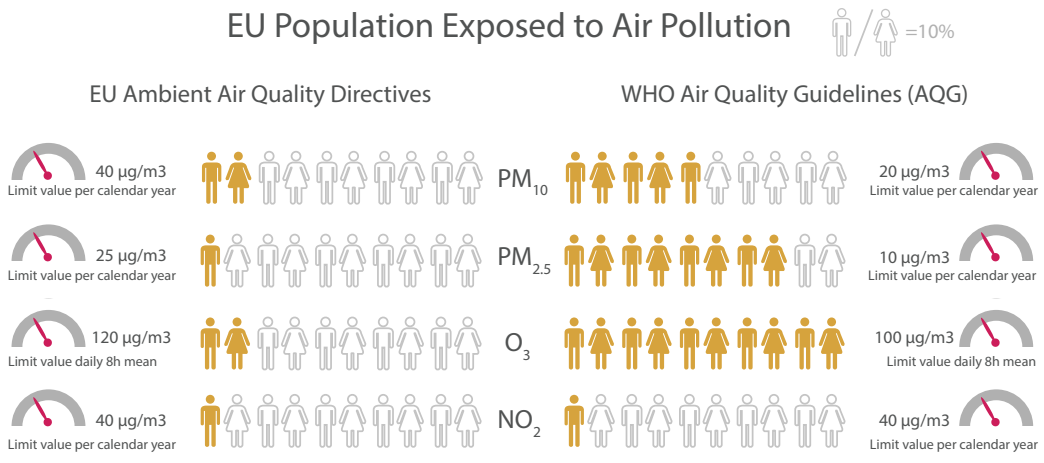


Figure 2.3 Air quality standards as given in the European Union (EU) Ambient Air Quality Directives and the World Health Organization (WHO) Air Quality Guidelines (AQG). And percentage of European (EU-28) urban population exposed to air pollution levels above those established by the EU Ambient Air Quality Directives and the WHO AQG between the years 2014-2016. Source: Guerreiro et al., 2018.

As can be seen in Figure 2.3, a considerable amount of the European population is exposed to air pollution, resulting in significant health, environmental and economic impacts. Although the EU establishes a framework for air pollution management, each country is individually responsible for setting values and monitoring levels and emissions.

2.1.2 Air pollution in the United Kingdom

Air quality legislation in the United Kingdom (UK) is derived from European legislation, whereby mandatory limit values must be met for several air pollutants (GMCA, 2016b). The two pollutants of most concern for the majority of areas of the UK are NO_2 and $PM_{2.5}$, as these show the highest concentrations (Figure 2.4) and can have severe health consequences for humans. Road vehicles are the predominant source for both pollutants (TfGM, 2016a).

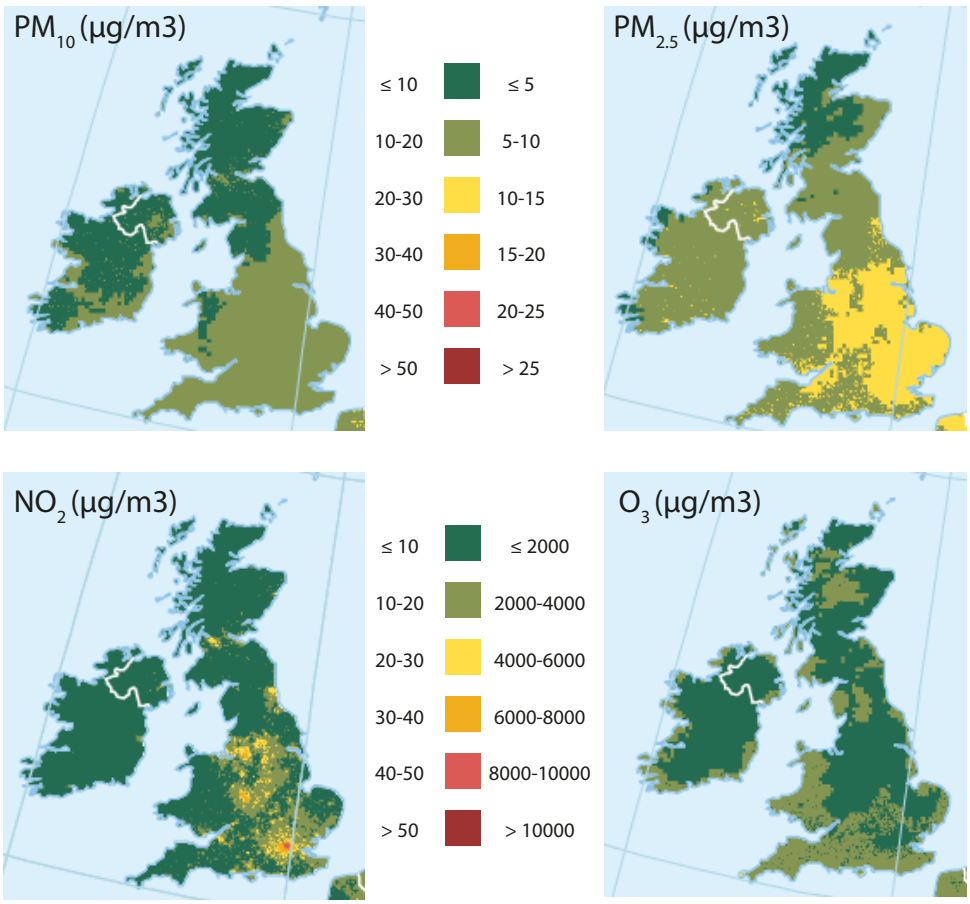


Figure 2.4 Spatially interpolated air pollutant concentrations for the United Kingdom (UK) for Particulate Matter (PM_{10} and $PM_{2.5}$), Nitrogen Dioxide (NO_2) and Ozone (O_3) for the year 2015. Adapted from: Horálek et al., 2016.

The Clean Air Act of 1956 of the Parliament of the UK was “an act to make provision for abating the pollution of the air” (Clean Air Act, 1956:1). It came into existence as a consequence of London’s Great Smog (1952). Health problems and premature deaths were attributed to this incident, but the thick fog also resulted in multiple road accidents and delays in transport networks. The Great Smog resulted in the introduction of smoke control areas, banning the emission of dark smoke from chimneys, trains, and industry. The Clean Air Act was revised in 1968, and gave rise to tall chimney policies, thereby ensuring that this toxic gas would be released away from built-up areas. As a consequence of these Clean Air Acts, the 1970s saw an improvement in air quality conditions in UK cities. Between the 1980s and 90s, however, there was an increase in the adoption of motor vehicles and pollution tied to vehicle emissions became of major concern (Clean Air Act, 1956; Defra, 2017). Triggered by this the UK government passed the Environment Act in 1995 (Defra, 2017), and devised a UK Air Quality Strategy which was made public in 2000, containing measures to be taken to improve air quality by 2005 by reducing the major air pollutants such as CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and O_3, mainly by focusing on the industry and transportation sector. The Air Quality Strategy has since undergone a series of reviews and was last updated in 2019, including more ambitious targets and goals in relation to emissions from transport, home, farming, and industry (Defra, 2019).

Currently, the Department for Environment, Food and Rural Affairs (Defra) co-ordinates assessment and air quality plans for the UK as a whole. Since 2000, local authorities across the UK have been conducting air quality assessments in order to keep within the national air quality objectives. If a local authority is hesitant about the likelihood of these objectives being met, an Air Quality Management Area (AQMA) is declared and a Local Air Quality Action Plan (AQAP) is designed for that specific area (Defra, 2018).

2.1.3 Air pollution in Greater Manchester

Greater Manchester (GM) is one of the largest metropolitan areas in the UK with 2.7 million inhabitants (UK Census 2011). It is composed of two cities, Manchester and Salford; and eight metropolitan boroughs, Bolton, Bury, Oldham, Rochdale,

Stockport, Tameside, Trafford, and Wigan (Figure 2.5). This conurbation, situated in the North West of England, is a combination of high-density urban areas, as well as semi-rural and rural locations. It is considered a central hub for transport in the North West, with multiple transport links and motorways, and in the past few years, the region has witnessed increasing levels of air pollution (Greater Manchester Resilience Forum, 2015; TfGM, 2016a; 100 Resilient Cities, 2017).

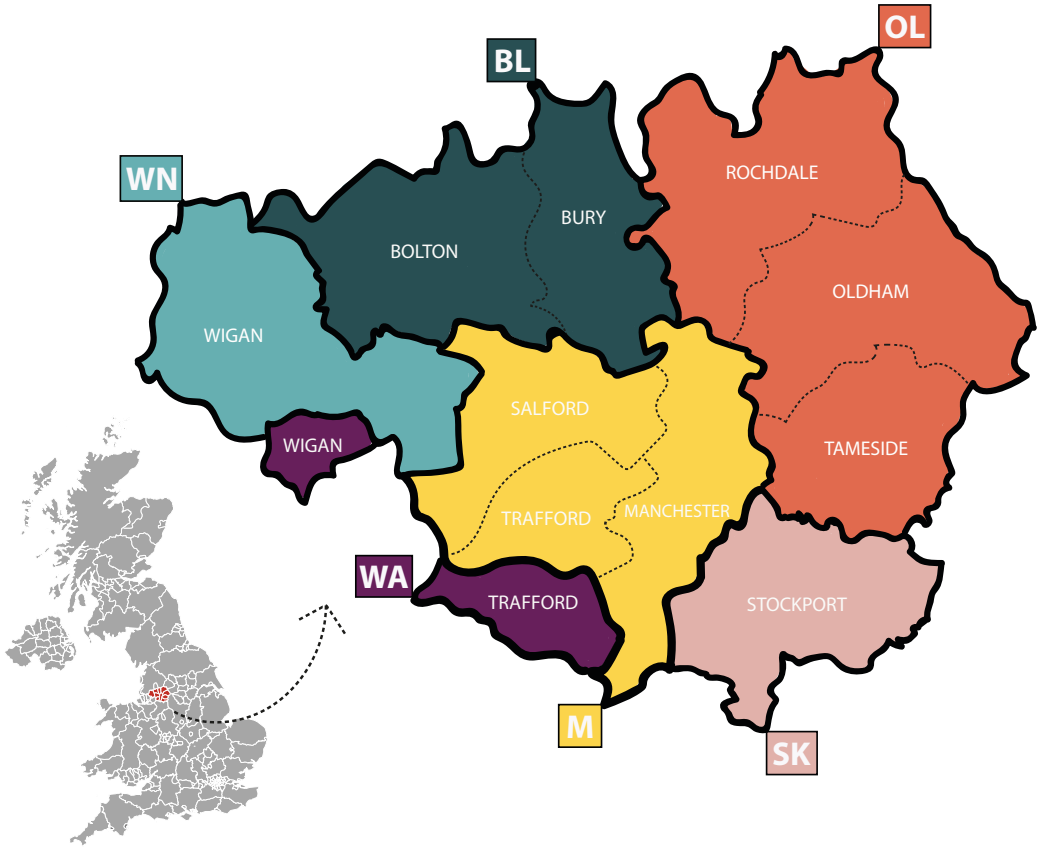


Figure 2.5 Location of Greater Manchester (GM) within the United Kingdom (UK), as well as a spatial representation of the different cities and boroughs of GM and the postcode areas they belong to.

The GM region, like many other regions in the UK, suffers from air pollution and closely monitors PM and NO_2 emissions. Although $PM_{2.5}$ and PM_{10} do not exceed annual limit values set by the EU (25 µg/m^3 and 40 µg/m^3 respectively) (Figure 2.3) (Guerreiro et al., 2018), this region is failing to meet limit values when it comes to NO_2 (TfGM, 2016a). According to the measurements from the diffusion tube network (of NO_2), many locations in GM, especially around the city centre and urban centres in the other nine councils, have recorded annual mean concentrations above or close to the annual limit set by the EU (40 µg/m^3) (TfGM, 2016a; Guerreiro et al., 2018). In some cases, annual concentrations have exceed

this threshold (reaching 65 µg/m^3)[3], especially around busy roads (e.g. Manchester Oxford Road) as vehicles are one of the most significant source of emissions (TfGM, 2016a; Guerreiro et al., 2018). In GM, road transport contributes 65% of Nitrogen Oxides (NO_x) and 79% of particulates ($PM_{2.5}$ and PM_{10}). The network of diffusion tubes for NO_2 can be seen in Figure 2.6.

Figure 2.6 The yellow pins in the map represent the locations of diffusion tubes that measure concentrations of Nitrogen Dioxide (NO_2) across Greater Manchester (GM). Source: Email communications with Matthew O'Neill, Air Quality Lead in Transport for Greater Manchester (TfGM).

Table 1 shows a description of each postcode district in terms of coverage of cities and boroughs, population, and air pollution levels (NO_2). Although the average air pollution levels recorded in all monitoring sites between 2011 and 2017 did not exceed safe levels in any of the postcode districts, individual records do occasionally exceed this threshold. Overall, postcode districts M and OL have the highest air pollution levels, whilst SK has the lowest air pollution level despite being the second most populous area.

[3] Email communications with Matthew O'Neill, Air Quality Lead in Transport for Greater Manchester (TfGM).

Table 2.1 Description of the six postcode districts in Greater Manchester (GM) in terms of: the cities* or boroughs they encompass, population percentage in relation to the total population of GM, air pollution levels (average Nitrogen Dioxide (NO_2) concentrations for all monitoring locations in each area between 2011 and 2015) – the World Health Organization (WHO) establishes an annual limit value of 40 µg/m^3. Sources: Census 2011; Email communications with Matthew O'Neill, Air Quality Lead in Transport for Greater Manchester (TfGM).

Postcode Districts	Cities or boroughs	Population %	Air Pollution (NO_2) (µg/m^3)
M	Manchester*, Salford* and Trafford (except Altrincham)	41%	34.4
SK	Stockport	21%	28.5
OL	Oldham, Rochdale, Tameside	16%	34.3
BL	Bolton and Bury	13%	33.3
WN	Wigan	5%	33.1
WA	Trafford (Altrincham) and Wigan (Golborne)	4%	31.6

In 2006, a single AQMA was declared for GM (TfGM, 2016a). The extent of the AGMA in GM can be seen in Figure 2.7.

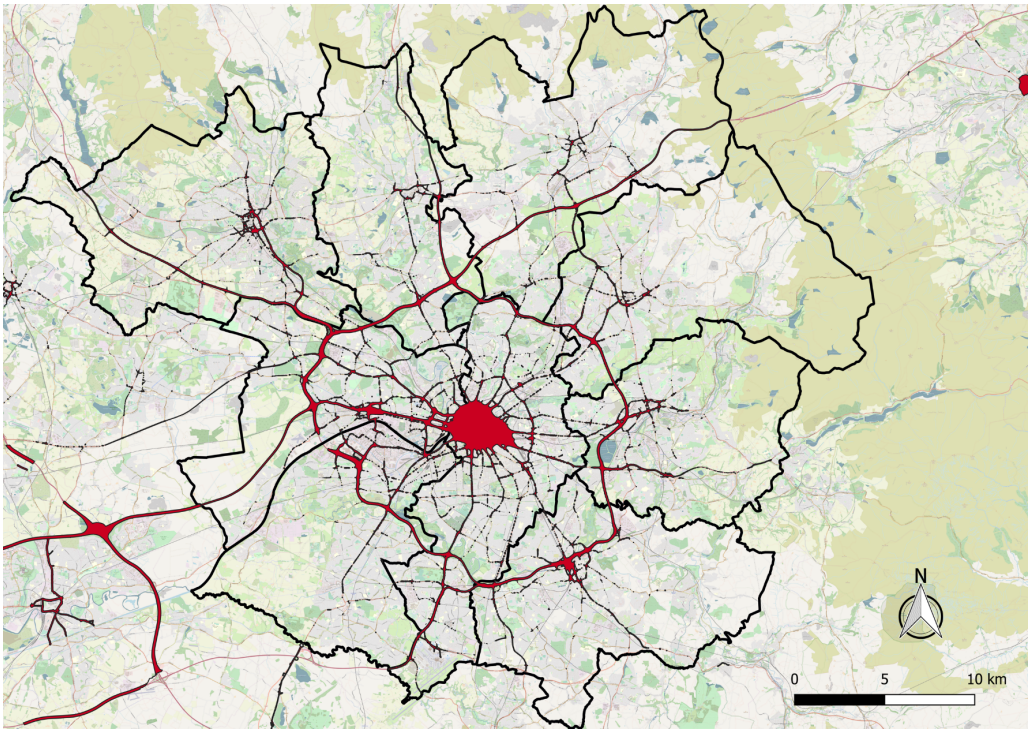


Figure 2.7 Extent of the Air Quality Management Area (AQMA) in Greater Manchester (GM) in red. The black outline shows the boundary of GM. Map background: Open Street Map. Software: QGIS 3.4.2. Source: 2019 AQMA Dataset. UK Air. Department for Environment, Food and Rural Affairs (Defra).

The GM region is currently undergoing a devolution process through which certain powers and responsibilities are transferred from the central government to this region. This devolution process is led by the Greater Manchester Combined Authorities (GMCA), which is run jointly by leaders of all ten councils and the elected mayor (currently Andy Burnham elected in May 2017). This has enabled GM to have more control over transport, planning, housing and health, all of which are connected to air pollution. In this context, there are a series of key documents that address local air quality in GM (Table 2.2). Some of these are concerned with air quality, such as the Air Quality Action Plan (AQAP), and others are broader in scope and cover aspects beyond air quality, such as the Greater Manchester Spatial Framework (GMSF). These documents are produced and issued through multiple collaborations by the three different lead organizations (TfGM, 2016a), namely:

(1) The Low Carbon Hub, which is a board composed of public, private, university, government, and volunteer representatives;
(2) Transport for Greater Manchester (TfGM), which is the local government body responsible for transport strategy across GM; and
(3) GMCA (Greater Manchester Low Carbon Hub, 2011, 2016; GMCA, 2016b; TfGM, 2016a, 2016b, 2016c).

Furthermore, Manchester City Council has endorsed the Manchester Climate Change Framework 2020-38 and the Manchester Climate Change Action Plan 2020-22, both of which have been designed by the Manchester Climate Change Agency (working independently from the local authorities) to reduce carbon pollution.

Table 2.2 Key documents tackling air quality in Greater Manchester (GM), the lead organization behind it, the years in which they are effective, and the main areas they provide guidance for.

Document	Lead Organization	Years	Areas
Climate Change and Low Emission Strategy	Low Carbon Hub	2016-2020	Buildings, energy, transport, greenspace and waterways, sustainable consumption.
Climate Change and Low Emission Implementation Plan		2016-2020	Energy, buildings, natural capital, transport, skills and sector growth, climate resilience, sustainable consumption.
Air Quality Action Plan (AQAP)	TfGM	2016-2021	Managing new development, freight and goods vehicles, buses, cycling, travel choices, cars, information and resources.
Low-Emission Strategy		2016-2040	Reducing emissions from transport.
Local Transport Plan		2040 1st Delivery plan 2016-2021	Creating an integrated, sustainable, and well-coordinated transport system offering a wide range of destinations and opportunities.
Greater Manchester Spatial Framework (GMSF)	GMCA	2018-2035	A joint development plan for the ten local planning authorities regarding: housing, green infrastructure, flooding, air quality, etc.
Manchester Climate Change Framework	Manchester Climate Change Agency	2020-38	Setting targets for reducing carbon pollution and becoming a carbon neutral conurbation.
Climate Change Action Plan		2020-22	Setting actions for reducing carbon pollution and becoming a carbon neutral conurbation.

Based on these documents, some of the initiatives that GM is considering and working towards are: improving public transport by increasing capacity and retrofitting it to reduce exhaust emissions; expanding electric car charging points

to facilitate and encourage the use of these type of cars; expanding and improving cycling and walking infrastructure; and potentially introducing Clean Air Zones.

The GM region is determined to change the way its citizens get around. The 'Beelines' project is a good example of an initiative that aims to bring about structural and behavioural changes. This initiative aims to promote active forms of transport that are consistent with the 1.5°C Paris Agreement target and the air pollution agenda and objectives. The aim of this initiative is to create an extensive joined up cycling and walking network. This is a response to social consultation initiatives suggesting that walking and cycling does not currently feel safe, attractive, or easy in GM. Furthermore, this major structural change comes hand-in-hand with engagement efforts aimed not only at involving citizens' experiential knowledge in early stages of the design process, but also at changing behaviours by offering, for example, bike maintenance and cycling proficiency courses (TfGM, 2018).

Greater Manchester (GM), and local authorities generally throughout the UK, are investing in information resources and public engagement activities to raise awareness about air pollution, and to encourage changes in behaviour in relation to transportation. Some of these initiatives are unique to GM, while others are part of broader UK-wide campaigns. Engagement initiatives include examples of one-way, as well as two-way communication. Engagement efforts often involve active participation, namely: playing a game, taking air pollution measurements, going on a bike ride or immersing oneself in air pollution pods as part of an art installation. These engagement activities are targeted at different audiences: from school children, their families, and teachers; to adults who are willing to explore air pollution through the arts. The table below (Table 2.3) offers a descriptive overview of a wide-ranging series of initiatives taking place in GM over the past year.

Table 2.3. Public engagement initiatives in Greater Manchester in 2019 aiming at raising awareness of air pollution, and encouraging changes in transportation behaviour.

Name	Description	Key elements	Location
Clean Air Manchester Resources	The unified information resource for air pollution in GM. Clean Air Manchester is a partnership composed of the 10 local authorities in GM, Greater Manchester Combined Authorities (GMCA), and Transport for Greater Manchester (TfGM). On their website (www.cleanairgm.com), citizens can access information about air pollution and its health impacts, as well as specific tips to reduce emissions at an individual level. Clean Air Manchester has created poster advertisements on trams and Metrolink stations with the slogan 'Dirty air is making us sick', encouraging people to 'care' about clean air and to visit the available educational resources (Clean Air Greater Manchester, 2019).	Website, educational materials, static advertising	GM
Clean Air Week Campaign	A yearly event that aims to raise awareness about unsafe air pollution levels across the UK, as well as to encourage behavioural changes in relation to transportation. Greater Manchester Clean Air Week in 2019 took place from the 17th to the 23rd of June. Official events included a series of bike rides across different areas of Greater Manchester, to raise awareness and visibility, and offer an opportunity for people to try out commuting by bike in a safe environment. Additionally, the campaign offered a series of resources (e.g. reports, leaflets, etc.) with ideas about what citizens can do at home, work, and in their community. It also offered support for people and hubs (e.g. universities, workplaces) who wished to organize awareness raising events, such as cycle-to-work events. The campaign also had an official twitter hashtag #CleanAirDay for people to share events, ask questions, or access information and resources about air pollution (Clean Air Day, 2019).	Social media, cycling events, educational materials	GM, UK
Pollution Pods	An art installation by Michael Pinsky, commissioned by the Cape Farewell Foundation	Art installation	GM, UK

	and TfGM. While in GM (June 2019), it was located in MediaCityUK. These pods allowed members of the public to experience different environments with ranging air pollution levels. The installation included five pods, each representing air quality in five different cities: Tautra (Norway), London, New Delhi, Beijing, and Sao Paolo (Clean Air Day, 2019).		
QualAIRty Game	A free online game designed by Clean Air Greater Manchester. The game is created as an educational resource for schools, and involves players cycling their way around the city avoiding the 'dirty air monsters'. The longer the player manages to stay on the bike avoiding these monsters, the higher the score. When the player fails to jump over a dirty air monster, an informational resource pops up in the screen. These resources containing messages in relation to detrimental health impacts of air pollution, or tips on how to cycle and walk safely (Clean Air Greater Manchester, 2019).	Game	GM
Clean Air for Schools Programme	The University of Manchester is behind this initiative that provides 20 schools across the UK with air quality monitoring devices and training. The programme aims to collect air pollution data (for $PM_{2.5}$, PM_{10}, NO_x, $C0_2$, and Ozone) across different schools, and to offer educational activities about how to reduce emissions. Targeted at school children, parents, and teachers (The University of Manchester, 2019).	Educational programme, citizen science	GM, UK

In summary, air pollution is a problem that requires cooperation from stakeholders at all levels; as well as a holistic approach involving not only technological development but also behavioural changes. Tackling air pollution is key for the EU's 2050 vision, that involves human well-being, protecting natural resources, and social and economic development (EEA, 2017). A cleaner air and a greener city region is also important for the GM vision of greater prosperity and improved quality of life for all (Greater Manchester Low Carbon Hub, 2011; TfGM, 2016a).

2.2 The public engagement challenge

The transition towards zero or low emission vehicles and active forms of transport requires rapid policy and lifestyle changes. There needs to be infrastructure in place, such as well integrated bike lanes and public transport; as well as a shift in personal travel choices in favour of walking or cycling rather than driving. Both of these important areas of action require public engagement. Even a carefully considered policy intervention can meet public resistance if this is not perceived to be convenient or relevant, and a change in lifestyle and personal travel choices requires public buy-in (Clarke et al., 2018; Perlaviciute, et al., 2018). Furthermore, citizens are not only "sources" of air pollution but also "victims" (Xu et al., 2017:2). Therefore, citizens not only need to be on board with mitigation strategies and adopt positive behaviours, but also need to know how to protect themselves if pollution levels are high.

Engagement, then, is not concerned with knowledge alone. The aim of engagement should not only be about citizens knowing the names and sources of different pollutants; nor about coming to terms with the fact that air pollution is a human-made problem affecting our health, the environment, and the economy. Engagement needs to go beyond such scientific literacy to encourage the adoption of positive behaviours. Effective communication in relation to the air pollution challenge we face today is therefore necessary for four reasons (Wilsdon and Willis, 2004b; Xu et al., 2017; Clarke et al., 2018; Perlaviciute et al., 2018):

(1) so that when air pollution levels are high people that are more vulnerable (e.g. asthmatics) know how to protect themselves,
(2) so that citizens are encouraged to modify behaviours through already available infrastructure,
(3) so that solutions that are not already available are put in place and met with public acceptance, and
(4) so that aware and engaged citizens are able to drive and enforce change from the bottom-up.

The public, however, are generally disengaged and not taking “sufficient” or “radical enough” action (Priest, 2016:25). Citizens are failing to grasp and prioritise this complex issue and consequently, failing to adopt positive adaptation and mitigation behaviours to avoid the health, economic and environmental implications coupled to air pollution. The disengagement of the public in relation to adopting pro-environmental behaviours has been described as a “communication emergency” (Ibid.). This emergency concerns the issuing of information about how to behave, what positive behaviours to adopt, and the many benefits coupled to already finalised policies and initiatives. It is also driven by a need to establish dialogues with the various publics so that policies as well as desirable protective, adaptation, and mitigation behaviours can be co-created.

2.2.1 A wicked problem

Although urban air pollution is affecting a very large population worldwide it is a challenging issue to convey. Air pollution can be described as a 'wicked problem', i.e. one which is complex and difficult to solve because of multiple interdependencies, uncertainties, and conflicting stakeholders involved (Rittel and Webber, 1973; Lazarus, 2009). The term 'wicked problem' originated in the 1970s. Since then, it has been studied across different scholarly disciplines, and in relation to broad ranging issues, such as governance, climate change policy, health care policy, natural resource management, urban planning, and terrorism (Lazarus, 2009; Head and Alford, 2015). Figure 2.8 offers an overview of the factors that make air pollution a wicked problem.

Figure 2.8 Six reasons that categorise air pollution as a wicked problem (i.e. one that is complex and difficult to solve).

Air pollution is an invisible threat (Number 1 in Figure 2.8), that is not easily grasped without the help of visual or olfactory cues, such as smoke emanating from factories, car congestion in main roads within an urban centre, or an uncomfortable odour when standing next to a running car (Bickerstaff and Walker, 2001). As is also apparent when communicating the negative effects of anthropogenic climate change, the non-immediate health and environmental impacts of air pollution can be difficult to perceive (Number 2 in Figure 2.8). For example, although people with asthma might have difficulties breathing when air pollution levels, emerging evidence suggests that it is the prolonged exposure that aggravates illnesses such as type 2 diabetes or obesity in adults (Guerreiro et al., 2018).

Furthermore, the outcomes of the behavioural or structural measures taken by citizens or policymakers do not offer instant gratification (Number 3 in Figure 2.8) as these are often only experienced in the longer term (Lorenzoni et al., 2007; Nisbet, 2009). Although banning cars from city centres would bring about an

immediate improvement in air quality, most of the solutions that are currently being taken have a long-term focus. For example, the 'Beelines' walking and cycling infrastructure initiative in GM, will help to tackle air pollution in the medium- to long-term as car journeys are gradually replaced by walking and biking (TfGM, 2018).

Furthermore, wicked problems are not mathematical problems with a defined solution (Rittel and Webber, 1973). These types of problems are about doing the best with the available resources for both policymakers as well as the public (Number 4 in Figure 2.8). Policymakers have a specific budget to invest in actions in relation to different areas. In GM, for example, policymakers have to coordinate all the concurrent action points outlined in the Air Quality Action Plan (AQAP), such as: securing a more reliable and punctual bus service; providing safety improvements at local accident hotspots for cycling; increasing the number of electric vehicle charging points; and improving public information resources. On the other hand, citizens face time constraints placed by day-to-day responsibilities or the comfort of the car over public transport in the characteristically inclement weather that occurs in GM.

Wicked problems also tend to be symptomatic of other problems (Number 5 in Figure 2.8) (Rittel and Webber, 1973). Air pollution could be seen as one of the symptoms of a congested city. Congestion is translated into road emissions and poor air quality, but also into a depravation of quality of life for its citizens, as well as delays to people and goods that affect productivity and deter potential investors. Congestion can be tackled in different ways and not all of these would be a solution to the air pollution problem. An improved transport system and incentives for citizens to use it would tackle both the congestion and air pollution challenges. However, if congestion is alleviated by providing more road space, the air pollution problem persists (TfGM, 2017).

Wicked problems present a “constellation of complex social and political factors” (Kreuter et al., 2004:442) perceived differently by the multitude of stakeholders who have contrasting understandings of the problem itself as well as its nature and causes (Number 6 in Figure 2.8) (Rittel and Webber, 1973). Industry and the public often interfere with science and policymaking to protect their interests and

profits. An example of this can be found in two UK cities. In 2005 in Edinburgh and in 2008 in Manchester, citizens voted against a congestion charge scheme in referenda with 61% and 79% of the votes respectively (Gaunt et al., 2007). Car owners were strongly opposed to the scheme and non-car owners did not fully grasp how these measures would be translated into an improved public transport system. Public resistance plays a major role in whether or not politicians implement measures even if these are often described as essential to reducing congestion and improving air quality (Gaunt et al., 2007; Steg and Vlek, 2009; de Groot and Schuitema, 2012; Carattini et al., 2018).

2.2.2 Public engagement

Although air pollution is a different issue to global warming and involves more pollutants than carbon, both these issues are essentially the same when it comes to public engagement. They call for an aware public that adopts positive behaviours, and participates in the development of science and policy. When it comes to transportation, this means the public needs to support investment and innovation that improves public transport, electric vehicles, and walking and cycling infrastructure; but also needs to use these in place of petrol or diesel cars. Because the literature in relation to public engagement with air pollution is scarce, some examples are taken from studies concerned with global warming or energy consumption and public engagement with low carbon or clean energy lifestyles (e.g. Kollmuss & Agyeman, 2002; Lorenzoni et al., 2007; Perlaviciute et al., 2018), which include electric vehicles and active forms of transport that are also central to clean air.

In this regard, the literature shows a knowledge-action gap. The literature shows widespread awareness and general concern as only 1% of the UK public has not heard about global warming or the greenhouse effect (Lorenzoni et al., 2007), and in the UK 40% of the population are fairly worried about it (Steentjes et al., 2017). However, action taken by the public in relation to these issues is limited, and they take low priority in relation to other day-to-day responsibilities, and reducing

energy consumption is not seen as a pressing matter (Lorenzoni et al., 2007; Steentjes et al., 2017).

Barriers to adopting positive behaviours, such as changing travel habits, reported by the UK public are: that day-to-day activities and responsibilities are more imperative; that often there is a lack of suitable initiatives and infrastructure; that they are uncertain about the positive impacts of their pro-environmental behaviours; and that there is a reluctance to make lifestyle changes (Lorenzoni et al., 2007; Steentjes et al., 2017). According to Kollmuss and Agyeman (2002), the likelihood of individuals reducing energy consumption (which could be understood as opting for active forms of transport) or taking other positive pro-behaviours is influenced by a series of external and internal factors: a combination of institutional, economic, social and cultural factors on the one hand; and environmental knowledge and awareness, feeling of responsibility, a positive attitude and motivation on the other.

When it comes to supporting initiatives or technologies, in relation to clean energy solutions, the public can adopt different stands such as “active resistance, apathy, uncertainty, passive acceptance, support, and embracement” (Perlaviciute et al., 2018:50). According to Perlaviciute et al. (2018), public acceptability is riddled with misconceptions and simplifications that fail to account for differences across groups of individuals, communities and initiatives themselves. It is often assumed that everything is reduced to a Not-in-My-Back-Yard (NIMBY) problem, in which the public is seen as irrational and ignorant; and that time, financial incentives and information will change behaviours. Financial incentives, for instance, have proven to be important but health and well-being benefits are sometimes valued more. Perlaviciute et al. (2018) also argue that, traditionally, public consultation has only taken place after a given initiative or measure has been challenged, and not at early stages of the design process.

Although there is agreement that the public is generally disengaged when it comes to reducing carbon emissions or changing travel behaviours, there seems to be disagreement as to why this happens. On the one hand, there is the argument that the public does not care or does not understand it (Owens, 2000; Moser and

Dilling, 2011). This is what is known as the 'deficit' model. This model adopts a “one-way, top-down communication process”, through which scientists fill “the knowledge vacuum in the scientifically illiterate general public” with the information they believe to be relevant (Miller, 2001:116). On the other hand, the 'dialogue' model turns the focus away from the public to look at how communication efforts have not been good enough to motivate and trigger a change in behaviour. This sets the focus on the communication process, and on how the communication has been both crafted and interpreted (Moser and Dilling, 2011). This model emphasizes the need to rethink public engagement and debate (Owens, 2000; Perlaviciute et al., 2018).

To date, most of the communication in relation to global warming and air pollution has adopted the 'deficit' model and has taken place through mass media (TV, newspaper, radio, Internet) under the assumption that it would reach a large number of citizens, with a generalized message and no possibility of tailoring messages to different audiences (Moser and Dilling, 2011). This type of communication lacks dialogue and shared understandings. The 'dialogue' model, as opposed to the deficit model, highlights that “while scientists may have scientific facts at their disposal, the members of the public concerned have local knowledge and an understanding of, and personal interest in, the problems to be solved” (Miller, 2001:117). However, even when public engagement has followed a dialogical approach it has often been governed by an incapacity to create a non-hierarchical and safe space for co-creation in which the public feels empowered to contribute knowledge and the experts are dissociated from authoritarian figures (Whatmore and Landström, 2011).

Genuine dialogue requires a 'substantial' approach to public engagement, in order to “improve the quality of decision-making, to create more socially robust scientific and technological solutions” (Wilsdon and Willis, 2004b:39). Specifically, substantial public engagement would require:

(1) a public that is aware or made aware of key debates,
(2) a public that is encouraged to deliberate jointly with the experts in contrast to only being allowed to voice an opinion,

(3) agreement that the goal is to reach consensus between the two (or more) parties involved, and not just exploring different views,
(4) breaking knowledge hierarchies and actively promoting the experiences, opinions, and agendas of experts and the public equally, and
(5) inclusion of under-represented groups or groups who usually hold more critical, strong, and dissimilar views (Wilsdon and Willis, 2004b:39).

In other words, if participation is not to be an empty and vacuous process it must come hand-in-hand with a redistribution of power. Levels of participation have been represented with the metaphor of a ladder. On the first rungs, there are efforts to educate people. These are followed by citizen consultation initiatives, where citizens have a say, but where it is uncertain how, or whether, those views are incorporated. The highest rung represents citizen control. This highest form of participation may be expressed in terms of partnership between citizens and traditional experts, when the process becomes a negotiation (Arnstein, 1969).

When it comes to how communication – about science in general and the environment in particular – is crafted and interpreted several factors have to be taken into consideration. The amount of information required to relate to a topic in a meaningful way varies from one individual to another. People rarely seek "all the science available"; rather, they want "enough" to be able to "make up their minds about an issue" (Priest, 2016:5). Sufficient information for one individual will not be enough for another, and information that exceeds or does not reach this threshold is unlikely to be effective. In other words, there is not a one-size-fits-all package of information able to engage society as a whole with regards to cleaner air.

In addition to the amount of information individuals need, the way this information is presented will also have an impact on how it is perceived and understood. The complexity of the topic, the technical level of the information, and the framing of the message have all been proven to influence the successfulness of communication, and these too are subject to individual differences (Bickerstaff, 2004; Burningham et al., 2008; Cacciatore et al., 2016).

Pre-existing knowledge is organized in what it is known as mental 'models', 'frames', or 'schemata' (Goffman and Berger, 1986; Lakoff, 1990, 2008, 2010; Scheufele, 1999). These can be described as mental infrastructures with interrelated categories of information. These structures are created for different concepts and are used not only to organize knowledge, but to guide and accommodate new information and future understanding. An analysis of these mental models can guide the creation of effective communication or provide insights into how a new measure or initiative will be seen or processed by different publics (Nisbet, 2009; Gifford and Comeau, 2011; Mir et al., 2016; Whitmarsh et al., 2019).

Framing is an unavoidable reality of the communication process; there is no such a thing as unframed information (Nisbet, 2009). A frame, however, is only effective if it is relevant to pre-existing knowledge and understanding (Nisbet, 2009; Whitmarsh et al., 2019). Framing is about emphasizing some aspects of an issue over others and the choice of the right frame can be key in developing effective communication (Druckman and Lupia, 2017). As an example, the need to reduce emissions has generally been framed as an environmental problem rather than a health or economic issue (Myers et al., 2012). That is, a transition to reducing carbon emissions by walking or cycling has been linked to benefits for ecosystems rather than to benefits to human health, such as reducing traffic fatalities or keeping physically active (Myers et al., 2012). Different studies, however, have shown that the health frame can be more meaningful, even among climate change sceptics, when it comes to discussing the need to cut down carbon emissions (Nisbet, 2009; Maibach et al., 2010; Myers et al., 2012). Framing that highlights an improved quality of life linked to more sustainable forms of transport also appears to be more effective than framing a transition to active forms of transport in light of sacrifice (Gifford and Comeau, 2011). Similarly, highlighting the gains of tackling air pollution is more likely to trigger environmentally friendly behaviours, such as sustainable forms of transportation, rather than highlighting the losses of not doing so (Mir et al., 2016). More generally, there has recently been a transition towards discussing climate change and anthropogenic emissions in relation to people and cities and to highlighting local impacts; that is, towards “carefully researched metaphors, allusions, and examples that trigger a new way of thinking

about the personal relevance of climate change" (Nisbet, 2009:15). There is, however, little research concerned with framing in relation to air pollution and transport choices specifically (Mir et al., 2016). Most research focuses on climate change and carbon emissions (e.g. Maibach et al., 2010; Myers et al., 2012; Nisbet, 2009; Whitmarsh et al., 2019). The need to explore framing in relation to different societal groups is also highlighted in this literature review (e.g. Gifford & Comeau, 2011).

The source of the information is another factor that influences how it is perceived and assessed (Rogers, 2003). "It is not just the message but the messenger, then, that matters" (Priest, 2016:56), and lack of trust in a source, such as the government, the media, or scientists, has proven to affect responsiveness to messages in relation to pro-environmental behaviours (Bickerstaff, 2004; Bultitude, 2011; Goodwin and Dahlstrom, 2014). The mere provision of evidence and information by a source perceived to be untrustworthy is unlikely to be effective. For instance, a lack of trust in the government can affect how people perceive policies in relation to reducing emissions (Priest, 2016), and air pollution. Similarly, studies show how information in relation to reducing carbon emissions or changing travel behaviours when presented as a moral issue and through religious leaders can be powerful in mobilising communities of faith (Nisbet, 2009; Moser and Dilling, 2011).

People reject information that goes against deeply held beliefs or that completely challenges their own lifestyles – a tendency known as 'cognitive dissonance' (Festinger, 1962; Lorenzoni et al., 2007; Priest, 2016). The fact that one's lifestyle is actually a root cause of air pollution, and consequently one has to modify established behaviours, is not easily accepted. Although individuals might not necessarily deny their contribution to air pollution, they are likely to take refuge in day-to-day obligations and priorities. Merely providing evidence is, therefore, unlikely to overcome this issue (Priest, 2016).

Indeed, even if a message had the right amount of information, the appropriate amount of complexity and jargon, and was framed in a suitable way, it would still ignore "the significant role of the environment and the individual as critical

determinants of that information's use" (Longnecker, 2016:4). Individuals are not passive receivers of information, ready to absorb and act upon the information received; they have values, emotions, needs, and previous experiences that will influence, not only the way the information is processed, but also the consequent action (or inaction) it triggers (Harre, 2011; Longnecker, 2016). Different individuals have different values and this defines what people find important in life. For example, biospheric values highlight the importance of preserving the environment, altruistic values stress the importance of caring for the well-being of others, egotistic values are concerned with securing one's well-being, and hedonic values seek pleasure and comfort (de Groot and Steg, 2008; Howell, 2013; Perlaviciute et al., 2018). Values influence public perception and acceptability, and communication that goes against these or fails to emphasize the right values will be discarded (Perlaviciute et al., 2018). Emotions are also important when processing information. Although it could be argued that emotions cloud judgements, there is a widespread agreement that emotions are important determinants in risk perception (Slovic et al., 2004; Roeser, 2012). That is, "emotions provide us with privileged epistemic access to moral values, especially when it comes to particular moral judgments where a complexity of moral considerations needs to be assessed" (Roeser, 2012:1035). Emotions such as anger or fear have proven to capture people's attention, motivating them to seek information about an environmental issue, while also disengaging individuals if they feel hopeless and/or overwhelmed. Feelings of hope and efficacy, on the other hand, are strongly correlated with a willingness to engage in pro-environmental behaviours and to support green policies (O'Neill and Nicholson-Cole, 2009; Moser and Dilling, 2011; Myers et al., 2012; Roeser, 2012).

Together with the individual, the environment in which individuals are embedded is also a critical determinant of how information is acted upon (Longnecker, 2016). The norms that govern communities, as well as what others think, have proven to influence an individual's behaviour (Cacciatore et al., 2016; Longnecker, 2016; Priest, 2016), and information that does not fit or which goes against these external factors is consequently likely to be discarded.

In brief, social studies dealing with public perception, focusing on individuals and the local environments in which they are embedded, are necessary to inform relevant policies, and to enable a better understanding of what catalyses or discourages positive action at the individual level (Bickerstaff and Walker, 2001; Johnson, 2012; Cisneros et al., 2017; Xu et al., 2017).

2.2.3 Public perception

Although air pollution is a global challenge, the experiences of air pollution are influenced by the local setting. The amount of greenery (such as vegetation and greenspace), the physical management of a place (such as litter accumulation or crime), as well as visual or olfactory cues (such as car fumes or proximity to clustered industries) influence how people perceive air pollution (Bickerstaff and Walker, 2001, 2003; Howel et al., 2003; Bickerstaff, 2004; Saksena, 2011; Johnson, 2012; Smallbone, 2012; Xu et al., 2017). These studies also show how a greater exposure to traffic, urban areas, dense population and industrial facilities are directly linked to perceptions of higher air pollution levels, and most often this happens regardless of actual air pollution levels.

Although people acknowledge the link between air pollution and health problems, this tends to happen at a more general than individual level, i.e. it is perceived to be a problem for society but not necessarily for oneself (Badland and Duncan, 2009). However, people living closer to industries, congested roads, or in city centres, as well as people suffering from certain illnesses such as asthma, are more likely to acknowledge that air pollution is directly affecting them in their day-to-day activities (Bickerstaff and Walker, 2001; Howel et al., 2003; Badland and Duncan, 2009; Saksena, 2011; Xu et al., 2017). Time spent outdoors is another factor; citizens with an active outdoor life, or who commute by foot or bike, are more likely to recognize air pollution as a problem and its resulting impacts on health (Bickerstaff and Walker, 2001, 2003; Saksena, 2011; Xu et al., 2017).

Signifiers of air pollution (such as greenery, vehicles, or industry) that vary from place to place, or time spent outdoors, are not the only factors influencing the

public perception of air pollution. Different studies have explored the role of age, income, education, and gender in shaping public perception. When it comes to age, for instance, studies have found that older populations are more aware of air pollution and its health impacts, whereas younger people appear to be less concerned (Lai and Tao, 2003; Becken et al., 2017). People with lower incomes have similarly reported air pollution levels as being worse than those with higher incomes (Kim et al., 2012; Chen et al., 2017). In terms of education, studies find contradictory results. Some find that people with higher levels of education perceive air pollution and its health impacts to be more threatening (Badland and Duncan, 2009; Kim et al., 2012), are more willing to pay for mitigation (Sun et al., 2016), and seek more information in relation to air pollution (Yang and Huang, 2018); others find that it is people with a lower educational attainment who appear to be more concerned (Lai and Tao, 2003; Chen et al., 2017). When it comes to gender, studies find either no gender differences (Howel et al., 2003; Kim et al., 2012) or that women report air pollution and risks related to health to be more threatening than compared to men (Flynn et al., 1994; Lai and Tao, 2003; Lepp and Gibson, 2003; Kahan et al., 2007; Cisneros et al., 2017). Similarly, there is a growing body of work exploring how women and men behave differently in relation to areas that are linked to the contribution and exposure to air pollution, e.g. transport and public spaces in cities (Basarić et al., 2016; Hanson, 2010; Madariaga, 2016; Polk, 2004, 2003; Root et al., 2000; Sweet and Kanaroglou, 2016).

In summary, social studies dealing with public perception are necessary for effective communication and engaging the public in positive behaviours and policy design. Furthermore, these studies must pay greater attention to the multiple publics that co-exist in one particular environment, as well as to further seek to understand groups in society that have traditionally been under-heard or underserved.

2.3 The gender challenge

Many cities in Western Europe are becoming more culturally and socially diverse, accentuating differences in how the environment is perceived and sustainable lifestyles conceptualised (Bradley, 2009). Characteristics such as occupation, income, gender, ethnicity, or age determine the environmental contribution and vulnerability of individuals and groups in society (Bradley, 2009; Kaijser and Kronsell, 2014). Such characteristics give rise to fundamental knowledge that originates from different circumstances and experiences (Kaijser and Kronsell, 2014), and consequently urban development that is environmentally, as well as socially, sustainable must in future comprise the views of these different societal groups and their relationships to the environment (Bradley, 2009). In other words, global environmental challenges, such as air pollution, require a more holistic understanding of human perception and behaviours, but also a careful exploration of different societal groups (Hemmati and Röhr, 2009).

A growing body of interdisciplinary research agrees that gender is central in dealing with carbon dioxide (CO_2) emissions and climate change (e.g. Denton, 2002; Johnsson-Latham, 2007; Christensen et al., 2009; Hemmati and Röhr, 2009; MacGregor, 2009; Polk, 2009; Kaijser and Kronsell, 2014; Pearse, 2017; Buckingham, 2018), sustainable mobility (e.g. Marion and Horner, 2007a; Polk, 2009; Hanson, 2010; Levy, 2013; Madariaga, 2016b; Buckingham, 2018), and energy consumption (e.g. Chalifour, 2011; Denton, 2002). An exclusion of a gender perspective in this context would be "insufficient, unjust and therefore unsustainable" (MacGregor, 2009:124), as it would fail to provide a more accurate diagnosis and response to the air pollution problem, and would be knowingly underserving the needs of women.

In existing literature, and in this thesis, gender is understood as being shaped by context and in interaction, that is "not only, or primarily, a characteristic of the individual, it is, importantly, also a property of collective groups of individuals where social practices, institutions and historical processes are constantly being constructed and re-constructed in the way they are associated with different interpretations of what it means to be a woman or man, and feminine or masculine" (Polk, 2009:75).

2.3.1 The need for a gender perspective

An explanation of why an exploration of gender is important when it comes to transportation and clean air can be found when looking at the concept of unpaid work. Unpaid work consists of a series of day-to-day responsibilities, such as grocery shopping and escorting children to school. These activities require time and effort but they are not considered when calculating Gross Domestic Product (GDP) (Madariaga, 2016b). These activities are sometimes performed by choice and sometimes by obligation; they are often combined with paid employment but can also be carried out as someone's only responsibility. However, most importantly, unpaid work disproportionately falls on women, shaping their mobility patterns and behaviours in the city and at home. In the UK, for example, 60% of unpaid work is performed by women (UK Census data 2011). According to Madariaga (2016b), many responsibilities that fall into the category of care work are not recognized as such by the people who perform them, especially in the case of middle-aged women. Consequently, care work is not fully reported in questionnaires or the census, and often in reality, these inequalities are more prominent.

The mobility associated with unpaid work, termed by Madariaga as "mobility of care", has been largely unexplored and greater importance has been given to transport linked to paid employment or leisure (Madariaga, 2016b). This mobility associated with unpaid work has been described as being invisible (Ibid.), albeit contributing to emissions and needing to be tackled. Unpaid work brings about a specific mobility: it is slower because it mostly involves travel with children, elderly, or disabled people (Bauer, 2009); it often involves walking as a form of transport (Madariaga, 2016b); it relies on public transport that is suitable for strollers or wheelchairs (Beebeejaun, 2017); and it often happens in the form of chained trips requiring multiple stops (Root et al., 2000; Madariaga, 2016b). This form of mobility tied to unpaid work is in turn translated into longer periods of time spent outdoors, often standing next to busy roads (e.g. waiting for a bus), and consequently results in a greater exposure to air pollution (Garcia-Ramon et al., 2004; Buckingham, 2016, 2018).

Similarly, beyond transport emissions, there is also an emphasis on the role of individuals as consumers to tackle emissions by, for example, reducing the use of wood-burning stoves or limiting meat consumption, which contribute to particulate and carbon pollution respectively. Because women are disproportionality in charge of household-related consumption and decisions (e.g. grocery shopping), the responsibility of living greener also disproportionally falls on them (MacGregor, 2009).

Economic inequality is another example of the importance of a gender perspective. Studies show that economic inequality is translated into a greater reliance on public transport (Polk, 2009; Alber, 2018) and less mobility (Johnsson-Latham, 2007; Alber, 2018). A pattern found in many European cities is that, although there are great variations within genders, overall, men travel greater distances and by more energy-consuming forms of transport (Johnsson-Latham, 2007; Polk, 2009; Pearse, 2017). Furthermore, there is agreement amongst climate scientists that women are more likely to be poor and that the more economically and socially marginalised people are, the more vulnerable they become to the consequences and restrictive policies of climate change and air pollution (Chalifour, 2011; Buckingham, 2016). Carbon taxes, for instance, have gendered effects. These taxes increase the price of carbon-intensive goods, which has a greater impact in low income households where women are over-represented, where there is no insulation, and which are more dependent on energy for heating (Chalifour, 2011).

Furthermore, biological differences between the sexes is also key in affecting mobility: as the life expectancy of women is longer than that of men, this also creates specific needs linked to reduced mobility in later life when it comes to transport and urban design, as well as a reliability on more energy-consuming households (Madariaga, 2016b). Similarly, physical strength and height are important when designing aspects of a transportation system (e.g. railings, positioning of control buttons). Pregnancy also shapes transportation needs and should be considered the norm rather than a special circumstance (Ibid.).

Fear of crime is another key example of the importance of considering gender, as it is an important reason for women's travel choices. In the literature, fear of crime Is about perceptions or feelings of insecurity, regardless of the likelihood of being attacked (Roberts, 2016a). Fear of crime varies from place to place, and can be subject to a specific time of day or week (Beebeejaun, 2017). Harassment towards women can be understood in two different ways: non-confrontational (in the form of words) and confrontational (in the form of sexual or physical assault). Although poorly lit stations or underground passages are places that women decide to avoid, much of this confrontational harassment takes places in rush hour and in crowded environments, where lack of space is taken as an advantage and where female victims might be unsure of whether this took place intentionally or unintentionally (Gardner et al., 2017). When it comes to choosing a form of transport, safety is sometimes valued over cost or travel duration (Root et al., 2000), and fear of crime can result in women avoiding public transport even if this is the most convenient option. The literature suggests that finding solutions for this is complicated: appropriate lighting and security officers might help with isolated and dark places at night, but some harassment happens in broad daylight. Having women-only carriages projects an image that women need to be protected and makes them more vulnerable (Gardner et al., 2017). Furthermore, those policies that work on modifying the victim's behaviour rather than that of the perpetrator, are policies that ultimately limit women's freedom (Whitzman et al., 2012; Roberts, 2013; Beebeejaun, 2017; Gardner et al., 2017).

The future of mobility needs to be environmentally friendly, accessible, cost-effective, and safe. And based on all of the above experiences, women are experts in this mobility. There is, however, an underrepresentation of women in policymaking when it comes to climate change, transportation, and energy. This exclusion takes place in two different ways: in the way climate change and related debates have been framed, but also in the numbers of women involved in policymaking (MacGregor, 2009; Kaijser and Kronsell, 2014; Gay-Antaki and Liverman, 2018). Although this thesis is concerned with air pollution specifically, the surrounding literature is limited, so the related area of climate change is also presented here in a discussion of how framing can serve to exclude women from important debates.

A number of scholars agree that there is a masculine bias in the way climate change has been tackled (Madariaga, 2016). MacGregor (2009) explains how climate change has been presented as a scientific and technological issue that requires complex and risky technologies such as carbon trading or carbon capture – also important considerations in tackling air pollution. Climate change has also been framed as a threat to national and international security due to factors such as scarcity of resources or mass migration. In her words, climate change has been 'scientized' and 'securitized' which are traditionally male-dominated disciplines, and which have excluded women from the debate (MacGregor, 2009:127). In this debate, the practicality of nuclear power has dominated over ethical issues on health concerns, and a quest for progress and a market-oriented focus over ethical consumption and sufficiency. A feminist-led debate would encourage social dimensions in the belief that technological solutions (which are of course important) are not sufficient to achieve a low carbon future (Hemmati and Röhr, 2009; MacGregor, 2009), and consequently clean air.

When it comes to policymaking, men have also been at the centre. First, because key sectors such as transport, engineering and technology have traditionally been male-dominated; and second, because an 'affluent masculinity' has been taken as the norm (Garcia-Ramon et al., 2004; Bradley, 2009; MacGregor, 2009; Polk, 2009; Kaijser and Kronsell, 2014; Pearse, 2017; Hemachandra et al., 2018). In this regard, “a predominantly middle-class, white, male car owner has taken precedence as the norm bearer” (Kaijser and Kronsell, 2014:428). That is, by and for whom polices have been created considering their needs, preferences and priorities (Polk, 2009; Kaijser and Kronsell, 2014). Policies in line with the norm of affluent masculinity have been designed following two different strategies: either the needs of men have been assumed to be the same as the needs and interests of all; or women have been ascribed special needs that deviate from those of (white) men, even if these needs are central to fulfilling family day-to-day responsibilities (Johnsson-Latham, 2007).

Under-representation not only takes place in the way climate change and other key debates related to air pollution have been framed, but also in the number of

women in policymaking. When looking at the participation of female scientists in the Intergovernmental Panel on Climate Change (IPCC), it can be see that in 1990 only 2% of scientists involved were women; 5% in 1997, 21% in 2001 and 22% in 2013, which shows an important increase but still a clear under-representation of women (Gay-Antaki and Liverman, 2018). When looking at specific sectors, transport and energy are heavily male dominated. In Scandinavian countries where women are well represented (e.g. in national parliaments), the transport sector, with clear contributions to greenhouse gas emissions and air pollution more generally, is still dominated by men (e.g. 66% of officials in the Danish Transport Authority are male) (Magnusdottir and Kronsell, 2015). In term of women's representation on energy company boards in Sweden, Germany and Spain, Carlsson-Kanyama et al. (2010) found that 65% had no women, and only 5% of the company boards had 40% or more women. Similarly, women's organizations are less likely to participate in United Nations Framework Convention on Climate Change (UNFCCC) forums than those related to other areas within the United Nations (UN) (Pearse, 2017), meaning that their experiences and knowledge are neglected in these debates.

Moss Kanter (1977) in a broader context argued that there needs to be a 'critical mass' for the presence of women to be reflected. This reflection would mean 'critical acts', that is, palpable policy and institutional changes (Dahlerup, 2006). In this regard, Ergas & York (2012) find that countries where women are better represented in policymaking or have a higher political status, have lower CO_2 emissions per capita – using control variables that have proven to be influential in other studies such as GDP per capita, urbanization, industrialization, militarization, world-system position, foreign direct investment, the age-dependency ratio, and level of democracy. A reason for this can be found in a different study explaining that a longer tradition of having women representatives has an "indirect effect on masculinity and men" leading to an "alternative expression of masculinity" that discusses climate change differently (Magnusdottir and Kronsell, 2015:320).

In summary, a gender perspective is not about depicting women as vulnerable, victims, mothers, or caretakers. A gender perspective involves empowering

women and acknowledging that they are experts, and that they are key and necessary to finding solutions for the global environmental challenges we face today. It is important to note that a gender perspective is not only about women. A transport system that is socially and environmentally sustainable, that helps meet the 1.5°C warming target and tackles air pollution, a transport system that facilitates combining unpaid work and paid employment, that is cost-effective, accessible, and safe is a transport system beneficial for everybody in society (Denton, 2002). Ultimately, a city that is more compact and better connected would encourage a greater sharing of responsibilities and would therefore also be contributing towards gender equality (Buckingham, 2016).

2.3.2 Gender mainstreaming and intersectionality

In this light, gender mainstreaming defends that gender considerations are central to climate change and air pollution governance (Kaijser & Kronsell, 2014). Gender mainstreaming can be defined as:

> "The process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres, so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is gender equality" (ECOSOC, 1997).

Gender mainstreaming is about identifying how the requirements to fulfil day-to-day activities are different across genders, but importantly, it has to go beyond this to also explore the factors that lead to these differences (Damyanovic, 2016). The most common criticism of gender mainstreaming is that it is not transformative, and that it accepts differences and caters for them (Roberts, 2016b). In order to avoid this, gender mainstreaming has to improve efforts to tackle these environmental issues by improving the relevance and effectiveness

of policies, while also working towards equity in a broader sense (Hemmati and Röhr, 2009).

Gender mainstreaming is necessary to avoid strengthening the position of those who are already more powerful; those who shirk unpaid work and family responsibilities, are in a position of economic advantage, do not have accessibility problems, and feel safe in the city (Madariaga, 2016b). Furthermore, in the case of unpaid work specifically, ignoring the associated needs makes these activities more effortful and time-consuming, which in turn makes it more difficult for the people who perform them (i.e. women) to juggle unpaid work and paid employment, contributing to aggravating economic inequality and reducing the likelihood of these being shared equally between genders. Gender mainstreaming in this case would first bring about more relevant and just policies for women, and then the conditions that encourage a sharing of responsibilities and gender equality. Ideally, gender mainstreaming needs to aim to consider differences between women that arise from age and life situations, as well as ethnicity or social background (Damyanovic, 2016). That is, it has to work to consider intersectionality.

The concept of intersectionality originated from Black and Minority Ethnic (BME) scholars claiming that feminist scholars at the time were middle-class white women advocating for their specific needs – not representative of those of other women with different social identities, such as race (Shields, 2008). This comes from the idea that the same individual can experience power and oppression simultaneously, i.e. that a middle-class, white woman will be in a position of advantage if compared to a middle-class BME woman (Ibid.).

Intersectionality explains that gender intersects with other social identities such as race, income, education, age, marital status, or job situation, encompassing very many different voices. For example, it is not the same to talk about the knowledge that comes from the experience of a female farmer or a female academic, and nuances are important in talking about a female perspective as these positions will give rise to different knowledge (Kaijser and Kronsell, 2014). The aim of intersectionality is to avoid the simplification of assuming that

knowledge generated by women is a universal aspect of being female (Ibid.). Intersectionality then sees this knowledge as dependent on their position in society.

Although it is important to consider women in their diversity and acknowledge that there are different social identities intersecting with gender, talking about women as a group in society is still important. Talking about women as a group is necessary so that policies in relation to transport, households, and the city become relevant to them and are therefore more effective in shaping a sustainable future. As Madariaga puts it, "in male-dominated institutional settings, where gender is still a new concept, frequently imperfectly understood and often resisted, simplification, at least at the present time, is a must" (Madariaga, 2016a:330). In other words, at the present time, both the white middle-class woman who holds a position of advantage and the middle-class woman of colour, are in a position of disadvantage if compared to the middle-class, white, male by whom and for whom transport policies are created.

Intersectionality in this regard can come with negative effects; for example, if paying attention to other factors such as race leads to a disappearance of gender studies and policies. Madariaga (2016a) argues that this is the case in the UK where diversity has been a more prominent category, causing gender-specific categories to disappear from policy agendas. She argues that gender-specific approaches are needed and have to be treated as a standalone category, and that they should not get lost within a wider diversity category because "gender is a key structuring factor of society which provides the basis for the subordinate position of half of the population; it has a biological component that cannot be changed; and it has proved to be, among the many possible factors for discrimination, the most resistant to change across time and space" (Madariaga, 2016a:330).

2.3.3 Social sustainability

Debates about sustainability can no longer be centred in environmental sustainability alone, and a more holistic understanding is needed. Sustainable

development should refer to a development that is socially and environmentally just and where economic activity is organized to fulfil this purpose (Dempsey et al., 2011; Buckingham, 2016). To talk about environmental sustainability and about protecting the planet for present and future generations is problematic if this perpetuates today's social inequalities. In other words, "sustainability as a concept is only valid once we have achieved a balance we collectively agree is worth sustaining" (Buckingham, 2016, p. 21).

In today's European society, there are important inequalities leading to homelessness or child poverty, as well as discrimination based on gender, race, or sexual orientations. Similarly, as cities become more multicultural and diverse, development needs to guarantee equal access to opportunities, as well as to freedom and solidarity (Polèse and Stren, 2000; Buckingham, 2016). The Government of the UK defines sustainable communities as places that "meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life. They are safe and inclusive, well planned, built and run, and offer equality of opportunity and good services for all" (Dempsey et al., 2011). Social sustainability advocates for a better balance between cities and nature, and of special relevance to this study, between women and men (Polèse and Stren, 2000).

A key element of social sustainability consists of placing citizens at the centre: not only in the way that development is *for* the people in being socially just, but *by* the people in being participative and from the bottom-up (Polèse and Stren, 2000). Social sustainability highlights the importance of citizens being an active part in democratic processes and of being meaningfully involved in decision making (Ibid.).

Dempsey et al. (2011) have identified non-physical and physical factors that contribute to social sustainability and sustainable communities. Some of these are: education, justice, safety, community cohesion, and social inclusion; but also walkable neighbourhoods, attractive public realms, and accessibility on the other. They appear to be broad underlying concepts that can change from community to community, and within communities over time. Often these factors overlap with

factors that are important in relation to environmental sustainability. For example, accessibility to greenspace is important for social well-being and environmental conservation. Accessibility to jobs is another example. This is fundamental for social sustainability but it requires mobility, and will therefore also have an impact on environment sustainability.

2.3.4 Perception through gender lenses

The literature on how the perception of women differs from those of men in relation to climate change, global warming, air pollution, and the environment is rather limited. There are a number of studies concurring that although there are important differences within genders, generally the attitudes and perceptions of women are different to those of men. Women perceive air quality to be worse in comparison to men and are more concerned about environmental hazards in general (Flynn et al., 1994; Lai and Tao, 2003; Lepp and Gibson, 2003; Gifford and Comeau, 2011; Cisneros et al., 2017). Because women are more reliant on walking as a form of transport and spend more time outdoors conducting family responsibilities (Garcia-Ramon et al., 2004), this tends to engender a closer relationship with their immediate environment. This in turn is translated into a stronger belief that environmental quality is directly tied to well-being, and that traffic damages communities and makes it difficult to create bonds at the neighbourhood level (Root et al., 2000; Lai and Tao, 2003; Polk, 2003, 2009; Garcia-Ramon et al., 2004; Cisneros et al., 2017). In this regard, women report being more concerned about the damage to future generations than the economic impacts as a result of environmental hazards such as climate change (MacGregor, 2009).

Generally, the literature shows that women are more critical about car usage and are more accommodating of a sustainable transportation system. Women are more positive towards measures that can reduce vehicle contributions to environmental issues and that come hand-in-hand with a sustainable transport system such as congestion charges, carbon tax, speed limits, or closing town and city centres to all but electric vehicles (Polk, 2003, 2009). Similarly, women appear

to be more positive about investing in infrastructure that encourages active forms of transport such as cycling or walking (Polk, 2009). Women in European countries are more supportive of the climate-related policies taken by their governments, and expect their countries and the EU to take the lead in developing these (Hemmati and Röhr, 2009). Generally, women report feeling more competent to tackle these issues (Gifford and Comeau, 2011).

The aforementioned studies investigate gender through questionnaires, highlighting differences in how men and women conceptualize the environment and air pollution. An in-depth analysis of the perception and experiences of women through qualitative interviews or focus groups is, however, missing. This would bring a better understanding, not only of the differences that questionnaires begin to explore, but also a possible explanation of how these differences originate.

2.4 Summary and knowledge gaps

Public acceptability and engagement are key to the rapid policy and lifestyle changes needed to meet both the 1.5°C Paris Agreement target and the air pollution agenda and objectives. The public however, is disengaged. This is partly because air pollution is a 'wicked' problem that is not easy to grasp and prioritise, creating a number of barriers for engagement; and partly because communication efforts have been ineffective.

Traditionally, communication has been based on a 'deficit' model assuming a scientifically illiterate public (Miller, 2001). It has relied on mass media under the assumption that it would reach a large number of citizens, but with the inability to tailor messages to different publics. Even when public engagement has followed a dialogical approach, assuming local knowledge of the public and an understanding of the problems to be solved, it has failed to truly promote this knowledge and create an equal partnership with traditional power holders.

This chapter has articulated how communication efforts have, generally, been unsuccessful in providing the right amount of information relative to different groups of individuals; and how they have arguably promoted the environmental frame over others, whereas recent studies show that a health frame (i.e. highlighting health impacts) can be more meaningful. Communication has also disregarded the role of emotions, values, needs, and previous experiences, as well as the importance of the environment in which an individual is embedded in shaping perceptions towards air pollution and its communication.

This chapter has also highlighted the need for further studies that explore public perception, with a greater focus on groups in society holding different socio-political positions. Gender has been explained to be key in dealing with air pollution and mobility, as factors such as economic inequality or fear of crime shape the transportation practices of women. Women are experts when it comes to desirable behaviours, such as lesser mobility and a greater reliability on public transport or walking, yet women have been excluded from decision-making processes and necessary debates.

Moreover, the very limited number of studies dealing with the perception of women, with regards to air pollution risk perception, find differences when compared to those of men highlighting the need for further exploration. Significantly, when it comes to differences in perception, studies show that women have a stronger belief that environmental quality is directly tied to well-being and that traffic damages communities and makes it difficult to create bonds at the neighbourhood level. Similarly, women are more critical about car usage and are more accommodating of a sustainable transportation system. They are also more positive towards measures that can reduce vehicle contributions to environmental issues and which come hand-in-hand with a sustainable transport system, and are more positive about investing in infrastructure that encourages more active forms of transport such as cycling or walking.

This chapter has also discussed how promoting the voices of women can be translated into more effective communication and policies in relation to air

pollution and sustainable forms of transport in the short term, and can facilitate the sharing of unpaid work and gender equality in the long term.

To summarise, this chapter has drawn attention to three knowledge gaps or areas of research that need further investigation:

(1) There is a need to examine how dialogues can be established between experts and the public in relation to air pollution, and to discover which two-way communication formats are most suitable for this purpose.
(2) There is a need to explore public perception of air pollution further and pay special attention to different groups in society.
(3) There is a need for an in-depth exploration of the needs and experiences of women when it comes to mobility and the urban environment, so that travel habits that are most common among women, are seen as the norm and integrated more fully into the development of future cities and in tackling air pollution.

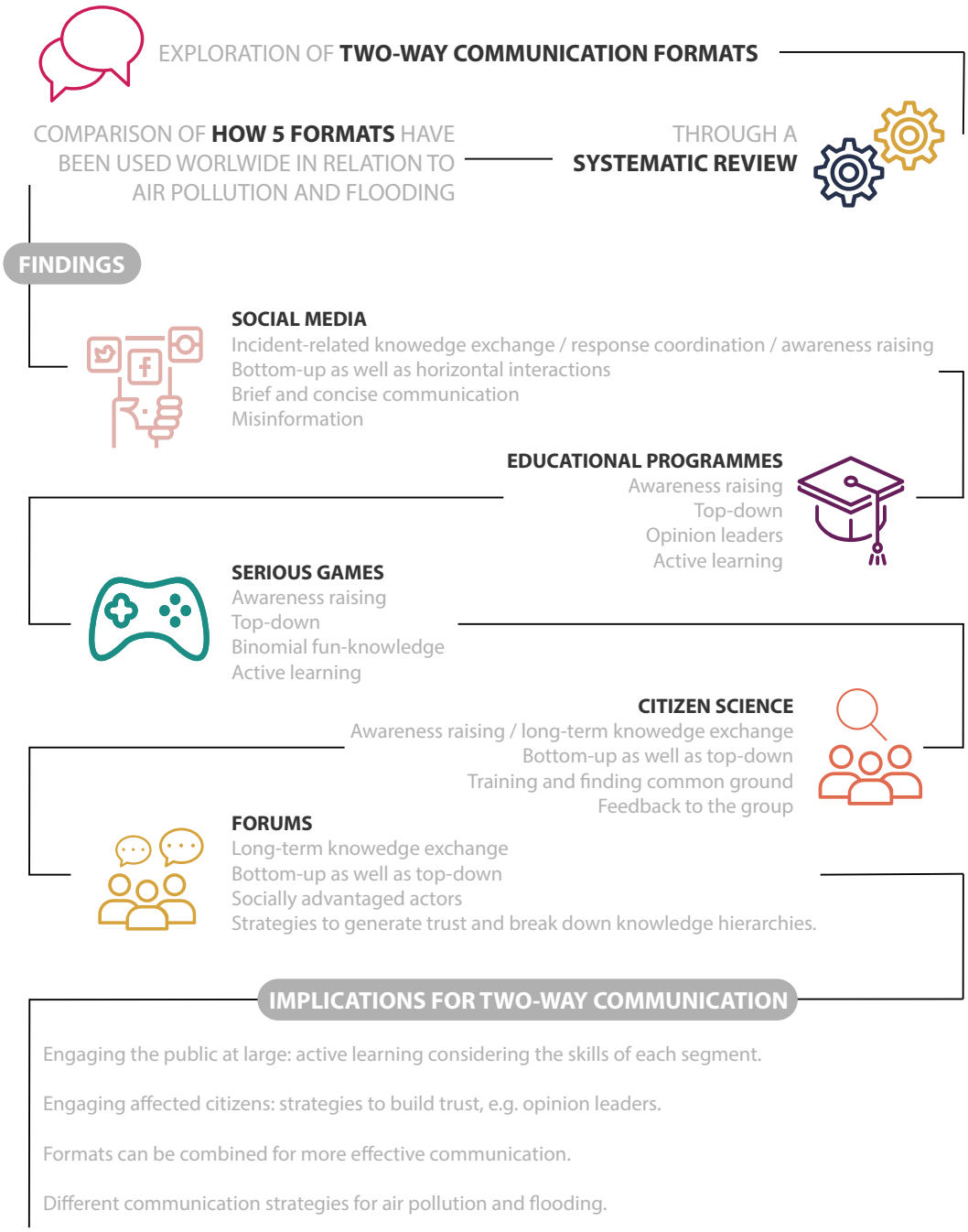
These three knowledge gaps have informed both the aims and methodology, and consequently the outcomes of this doctoral research programme.

Chapter III

Two-way communication between experts (with scientific knowledge) and the public (with experiential knowledge)

Infographic

Two-way communication in action



Overview

This chapter presents findings from a systematic review of fifty studies exploring how two-way communication can be established between experts (who possess expert or scientific knowledge) and the public (who possess experiential or local knowledge) (Miller, 2001; e.g. Rice et al., 2015). In order to provide a better understanding of the possibilities provided by two-way communication, this chapter offers a comparative analysis of five different communication formats (i.e. social media, educational programmes, serious games, citizen science, and forums) and two very different environmental threats that are of great relevance for Greater Manchester (GM) (i.e. air pollution and flooding). This chapter explores (1) how these formats can be employed in respect of three different communication purposes: dealing with incidents, raising awareness, and promoting knowledge exchange; (2) who is involved in these communication processes; (3) who controls these communication encounters; and (4) what strategies can be employed to improve communication between experts and the public. This chapter suggests that there is neither a one-size-fits-all nor a superior format of communication. No single format is effective in fulfilling all three aforementioned communication purposes, or in engaging multiple audiences with different backgrounds, abilities, and degrees of involvement simultaneously. Communication between experts and the public is difficult and full of tensions, and information alone is not enough for meaningful engagement. This chapter presents different ways of incorporating strategies to build trust between experts and the public and make communication more fun and accessible, breaking down hierarchies and creating safe spaces for co-creation where everyone feels empowered to participate and everyone benefits.

The core material presented in this chapter has been published as the following paper that can be found in Appendix 3.1:

Loroño-Leturiondo, M., O'Hare, P., Cook, S., Hoon, S. & Illingworth, S. (2018). Building bridges between experts and the public: A comparison of two-way communication formats for flooding and pollution risk. Geosci. Commun., 2, 39-53, https://doi.org/10.5194/gc-2-39-2019.

3.1 Introduction

Tackling global environment challenges, such as air pollution, requires public engagement so that: (1) policy interventions are relevant and effective, (2) citizens adopt the necessary lifestyle changes, and (3) in the short-term, citizens adopt protective behaviour if, for example, air pollution levels are high (Clarke et al., 2018; Perlaviciute et al., 2018). Aware and better prepared citizens are key to limiting the damage that a specific environmental risk brings to people, the economy, and the environment. Furthermore, citizens are instrumental in driving local solutions as they possess highly pertinent local and personal on-the-ground experience and knowledge (Environment Agency, 2001; Bickerstaff, 2004; Burningham et al., 2008; O'Hare et al., 2016). Therefore, with the aim of helping to promote local knowledge and experiences, this chapter explores how two-way communication formats can be employed and how dialogues can be established between experts and the public.

The awareness and preparedness campaigns for global environmental challenges, such as air pollution, have followed the premise that if citizens have information, they will be aware, prepared and ready to take action (Bickerstaff, 2004; Burningham et al., 2008). This aligns with a 'deficit model' in which citizens are passive receivers of information and experts fill the knowledge gap through a one-way form of communication to the public (Miller, 2001). However, citizens are not passive receivers of information; they are active, critical, have values and beliefs, and possess lay knowledge as well as relevant previous experiences (Longnecker, 2016). One-way provision of information does not, therefore, realise the full potential of knowledge transfer. The discrepancies of information with people's personal experiences of, for example, air pollution, together with an excessive use of technical language, as well as the challenge of presenting ambiguity and uncertainty in complex topics, are some of the factors that can debilitate the communication process (Bickerstaff and Walker, 1999; Bickerstaff, 2004; Burningham et al., 2008). The existing climate of mistrust between the public and (some) experts is another factor that can limit the effectiveness of communication (Slovic, 1999; Bickerstaff, 2004; Goodwin and Dahlstrom, 2014; Weingart and

Guenther, 2016). The government and the media, for instance, are not seen as being very trustworthy, mostly due to a suspicion about their respective political agendas, which may be at odds with doing their best for the public good (Bickerstaff, 2004; Priest, 2016; Weingart and Guenther, 2016).

Promoting local perspectives and on-the-ground experiences and facilitating knowledge exchange between experts and the public is key in tackling air pollution and other environmental issues, but a challenge nonetheless. Public engagement for knowledge exchange purposes has proven to be governed by an incapacity to create a non-hierarchical and safe space for co-creation in which the public feels empowered to contribute knowledge, and the experts are dissociated from any authoritarian figure (Whatmore and Landström, 2011).

Central to this line of work is the need to move away from a one-way provision of information, and to explore how two-way communication can be established. There is a need to examine which two-way communication formats are available, and to ascertain which of these are more suitable for raising awareness and which would allow substantial engagement and expert-public knowledge partnerships. It is also important to investigate who are the actors within two-way communication processes, and who initiates or controls them.

Whilst several recent studies have focused on one single communication format in particular (e.g. Lo et al., 2013; Leon et al., 2015; Sîrbu et al., 2015; Bosschaart, van der Schee and Kuiper, 2016; Breuer et al., 2017), and a single environmental hazard at a time (with very few exceptions combining multiple threats (e.g. Rodriguez Bermúdez et al., 2015)), this study explores an overview of possibilities. A comparison across formats and across environmental problems that are different in nature can offer better insights into the possibilities provided by two-way communication.

This study offers a comparison across five different formats embracing two very different environmental risks: air pollution and flooding. The reason for the inclusion of flooding in this part of the study is twofold: first, because flooding and

air pollution are disparate; and second, because it is of great relevance for the case of Greater Manchester (GM), in which this study is based.

Flooding is discrete in time, visual, and tangible as it has immediate consequences on people and infrastructure. Air pollution, on the other hand, is more difficult to grasp as it is a continuous threat, generally described as being invisible in many urban centres, and having non-immediate health impacts. Different studies show how sensory cues (visual or olfactory) are necessary for people to relate to the otherwise intangible air pollution (e.g. Bickerstaff and Walker, 2001).

Although air pollution is an important threat for citizens in GM, this is not the only environmental issue that this region faces. In the past few years, GM has witnessed a series of flooding incidents. During the Boxing Day floods in 2015, more than 2,000 homes and 500 businesses were flooded, and damage to infrastructure totalled £11m (GMCA, 2016a). In August 2019, for example, heavy rainfalls caused flooding in GM again: properties and vehicles were damaged, and roads were badly disrupted roads causing delays in public transport and challenging driving conditions (BBC, 2017; Manchester Evening News, 2019). It has been established as a priority for this conurbation to reduce floods when possible, and manage their impact when flooding is inevitable (Greater Manchester Resilience Forum, 2015, 2016). Similarly, as will be presented in Chapter IV, when citizens of GM were asked about what environmental issues they felt most affected by as residents in this region, they reported pollution followed by flooding.

This chapter is concerned with **research question one (RQ1)** presented in Chapter I: what two-way communication formats can be used for establishing dialogues between experts (with scientific knowledge) and the public (with experiential knowledge) in relation to air pollution, and how?

3.2 A systematic review as a research method

Since the early 1990s, systematic reviews have been accepted as a legitimate research method (Boland et al., 2013). Systematic reviews can be defined as:

> "A literature review that is designed to locate, appraise, and synthesize the best available evidence relating to a specific research question in order to provide informative and evidence-based answers" (Boland et al., 2013:2).

Although they originated in healthcare sciences, they have now become an increasingly popular research method in relation to many other fields (Ibid.). They are increasingly being used in environmental sciences (e.g. Groulx et al., 2017), and are often employed to inform policies or support practice (Petticrew and Roberts, 2005).

Unlike a literature review, systematic reviews are valid tools to answer research questions and test hypotheses; they are "less of a discussion of the literature and more of a scientific tool" (Petticrew and Roberts, 2005:10), and offer "informative and evidence-based answers" to research questions (Boland et al., 2013:3). Systematic reviews can be a research method that provides answers to questions about "what works and what does not" (Petticrew and Roberts, 2005:2). Systematic reviews also offer a "replicable and transparent process" (Groulx et al., 2017:57) in which a study pool is created based on a well-defined search protocol and a set of inclusion and exclusion criteria (Petticrew and Roberts, 2005; Ford et al., 2011; Boland et al., 2013; Groulx et al., 2017; Lumbroso et al., 2017). The benefit of using a systematic review as a research method is that it allows "making sense of large bodies of information" (Petticrew and Roberts, 2005:2). Furthermore, it allows gathering vast amounts of data that would otherwise be very time-consuming to collect (Boland et al., 2013).

In this study, a systematic review allows analysis of an array of communication examples in multiple locations around the globe, about 'what works' in relation to

two-way communication of flooding and pollution, and consequently support communication practice (Petticrew and Roberts, 2005).

The process followed in the systematic review is outlined in Figure 3.1.

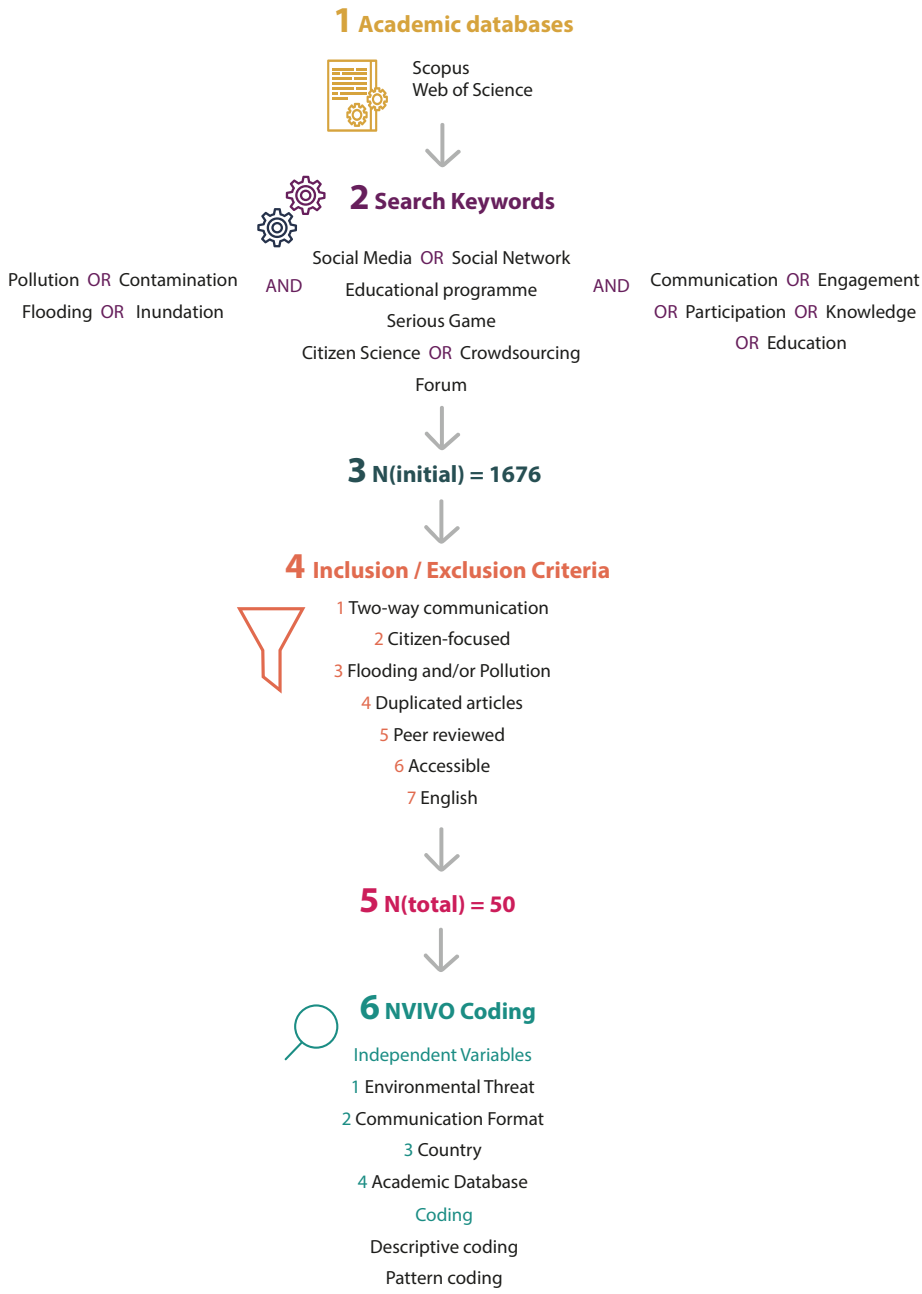


Figure 3.1 Overview of the systematic review methodology, stating: (1) in which academic databases the search was conducted; (2) the different selected search keywords and in which parts of the articles the search keywords were looked for; (3) the initial number of retrieved articles; (4) the applied inclusion and exclusion criteria; (5) the final number of articles to be analysed; and (6) the coding exercise.

3.2.1 Search strategy

This review emulates the technique used by (Groulx et al., 2017), as their analysis of the different learning outcomes of citizen science projects is similar in approach to the aim of this study of investigating communication outcomes of different two-way communication formats.

The metadata searches for this systematic review were conducted in two large and multidisciplinary academic databases: Scopus and Web of Science (step 1 in Figure 3.1). Two databases were selected to assure that findings are not specific to one database in particular, but that the number of retrieved studies to be analysed was still manageable for one researcher alone. Furthermore, these two databases provide broad coverage of interdisciplinary research.

The systematic review was limited to formats that allow two-way communication, i.e. where there are two 'communicators' who issue and receive information (Bowater and Yeoman, 2012). Two-way communication can take many forms, but for the purpose of this review anything was accepted from face-to-face dialogues, to communication composed through posts and comments on social media. These formats include: (1) social media; (2) educational programmes; (3) discussion forums, that is, collaborative encounters where experts work closely with affected communities (Whatmore and Landström, 2011); (4) serious games, that is, those which exceed mere entertainment purposes and also intend to educate (Abt, 2002); and (5) citizen science projects, which can be described as “collaborative research that involves members of the general public (or citizens), and which actively involves them collecting, generating, and analysing data” (Illingworth and Allen, 2016:5–12).

This list of formats was informed by an initial literature review of the field (Whatmore and Landström, 2011; McCormick, 2012; Aubert et al., 2015; Fohringer et al., 2015; Pennington et al., 2015; Amri et al., 2016; Gravina et al., 2016; Mani et al., 2016; Salvati et al., 2016), and in discussion with stakeholders in urban risk management, namely the Association of Greater Manchester

Authorities (AGMA). The initial literature review also revealed that the search strategy had to account for terminological synonyms and alternative denominations. For example, 'flood' is often used interchangeably with 'inundation'. Finally, the literature review elucidated that other terms had to be considered together with 'communication', such as: engagement, participation, knowledge, and education. Search keywords were linked using the Boolean operators AND/OR, and the search was programmed to retrieve articles containing these search terms in the title, abstract, and keyword sections (step 2 in Figure 3.1).

The initial number of retrieved studies was 1676 (step 3 in Figure 3.1)

3.2.2 Inclusion and exclusion criteria

Not all of the articles retrieved in these searches were relevant and thus a set of seven inclusion (or exclusion) criteria was designed (step 4 in Figure 3.1):

- Criterion 1 (Two-way communication) was designed to include only articles addressing two-way communication. For example, articles dealing with flyers and leaflets in mailboxes as educational propaganda were retrieved under the term 'educational programmes', but these formats do not permit interaction between experts and the public.
- Criterion 2 (Citizen-focused) ensured that articles were only included where they explained how the communication process impacted the citizen. For example, explaining how participants became more aware of a risk or how their input was incorporated into policy. Articles dealing with data mining, in which users do not realize that their data are being taken into consideration were discarded.
- Criterion 3 (Flooding and/or air pollution) was included so that only articles dealing with flooding and air pollution were selected. Sometimes, other types of pollution, such as water pollution, came up. Additionally, several HIV prevention campaigns were retrieved under the category

'contamination' (terminological synonym of pollution) although they were not relevant for this study.

- Criterion 4 (Duplicated articles) removed duplicate articles. Some of the articles came up under two different communication formats when these were used simultaneously, and had to be removed from the secondary category.
- Criterion 5 (Peer reviewed) assessed whether the article was published in academic and peer-reviewed literature (i.e. conference proceedings).
- Criterion 6 (Accessible) was related to accessibility, and how the articles needed to be available via Open Access (i.e. not behind a paywall). As this criterion significantly reduced the number of papers available, studies were also considered if available through the Manchester Metropolitan University library, or fully and freely accessible through Research Gate – a social networking site for researchers – via author elective uploads.
- Criterion 7 (English) ensured that, for practical reasons, only articles written in English were considered.

The final number of relevant studies to be analysed was 50 (step 5 in Figure 3.1).

3.2.3 Data analysis: coding

The methodology adopted for the data analysis in this study was content analysis (step 6 in Figure 3.1). Content analysis can be defined as a research method that allows the "subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh and Shannon, 2005:1278). Content analysis can be applied to a multitude of data sources including documents. Although content analysis was traditionally used for quantitative analysis of qualitative data (i.e. counting codes and categories), it can also focus on an in-depth analysis of language and words (Hsieh and Shannon, 2005).

This study employed a conventional approach to content analysis, in which preconceived categories were avoided and the generation of codes was guided by

the data and RQ1 (i.e. What two-way communication formats can be used for establishing dialogues between experts (with scientific knowledge) and the public (with experiential knowledge) in relation to air pollution, and how?). This approach is relevant when the theory or literature is limited, when there are no preconceived categories, and when the researcher's role is to derive these categories from the data using an inductive approach (Hsieh and Shannon, 2005).

The coding process was implemented based on this inductive and interpretative approach to data analysis. A code in qualitative research is: "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldana, 2009:3). In qualitative data analysis, a code is not an exact science, rather it offers an interpretative meaning of the data, just as a "title represents and captures a book, film, or poem's primary content and essence" (Saldana, 2009:4).

The articles were coded for qualitative data analysis using the NVIVO software (Version: 10.2.2). All the articles were assigned four independent variables: country, environmental threat (flooding or air pollution), format of communication (social media, serious games, educational programmes, citizen science, or forums), and academic database (Scopus or Web of Science). The coding exercise was developed in two cycles. Firstly, the data were analysed through a method called 'descriptive coding' (Saldana, 2009), which allows the attribution of a label that describes the basic theme of a paragraph. Secondly, the data were later re-coded using a method called 'pattern coding' (Ibid.), finding relationships between codes and grouping data into more meaningful units. The coding exercise took place first with the articles retrieved from Scopus, and the articles in Web of Science were used to prove data saturation (i.e. thematic exhaustion) (Bryman, 2012).

For example, the following sentence found in one of the analysed documents was coded in the following way:

"Access, post and share information about road closures, flood peaks" (Bunce et al., 2012:37)

First cycle coding: WARNING AND INFORMATION

Second cycle coding: INCIDENT ORIENTED

Third cycle coding: SHORT-TERM COMMUNICATION

In order to guide the coding process and make it more transparent a codebook was developed (DeCuir-Gunby et al., 2011). A codebook is a compilation of codes and definitions that is "essential to analysing qualitative research because they provide a formalized operationalization of the codes" (DeCuir-Gunby et al., 2011:138). The codebook generated in this study can be found in the four tables below (i.e. Table 3.1, 3.2, 3.3, and 3.4). These tables present the codes, a description of what these codes represent, and the categories which these codes were later grouped into. In this regard, categories are groups of codes that share some characteristics (Saldana, 2009). Table 3.1 shows how the codes originated in relation to the purpose of communication. Table 3.2 shows the codes in relation to the direction of communication. Table 3.3 shows the code in relation to the people involved in the communication process. And table 3.4 shows the codes in relation to catalysers and barriers for communication.

Table 3.1 Codes originated from the analysed papers in relation to the purpose of communication.

Code	Description	Category	
Warnings / Information	References to sharing information before, during and after an emergency event.	Incident oriented	Short-term communication
On the ground information	References to citizens sharing observations about the place where they are at about how an emergency event is unfolding.		
Coordinating response	References to sharing information about the aftermath of an emergency: donations, accommodation for victims, etc.		

Raise awareness / understanding	References to the public becoming more aware of the existence of flooding or pollution and increasing their knowledge and understanding.	Raise awareness / Behaviour change	Long-term communication
Behavioural change	References to the public adopting positive mitigation, adaptation or protective behaviour in relation to flooding or pollution.		
Encourage debate	References to the public and experts changing ideas, information and opinions in relation to flooding and pollution.		
Campaigning	References to putting pressure so that different action is taken by citizens or governments in relation to flooding and pollution.		
Gathering data	References to collecting measurements, images, etc. in relation to flooding and pollution.	Knowledge exchange	
Knowledge production	References to the production of knowledge combining expert and non-expert knowledge.		

Table 3.2 Codes originated from the analysed papers in relation to the direction of communication.

Code	Description	Category
Downstream	References to communication being two-way but controlled by the experts.	Direction of communication
Upstream	References to communication being two-way but controlled by the public.	
Horizontal	References to communication being two-way from citizens to citizens.	

Table 3.3 Codes originated from the analysed papers in relation to the people involved in the communication process.

Code	Description	Category
Scientists	References to researchers, lecturers and professors in university or research centres.	Experts
Government officials	References to urban planners, civil servants, policymakers working at national or local government.	
Response teams	References to police officers, ambulance crews, fire fighters, etc. needed in an emergency event.	
NGOs / GOs / ENGOs	References to people working on non-governmental, governmental, or environmental organizations.	
Teachers	References to school teachers.	Mediators
Opinion leaders	References to people who are trusted, respected and have relevant skills and expertise to be considered knowledgeable in relation to flooding and pollution.	
Citizens / Public	References to the general public or citizens at large.	The public
Affected communities	References to segments of the public who are directly affected by flooding or by pollution to a greater extent, either due to location or to them being more vulnerable.	
Elderly	References to senior citizens.	
Children	References to citizens below the legal age.	
Indigenous communities	References to citizens who are native to a specific country.	
Small or home-based businesses	References to people working in small businesses often from home who are difficult to target.	

The category 'mediators' refers to those actors who are involved in facilitating knowledge acquisition or exchange. These actors might be experts when it comes to education (e.g. school teachers), but not necessarily in relation to the issue at hand (e.g. flood management or air pollution). Often 'mediators' undergo a

process of training about the educational programme or citizen science initiative at hand (Bosschaart, van der Schee and Kuiper, 2016).

Table 3.4 Codes originated from the analysed papers in relation to the catalysers and barriers for communication.

Code	Description	Category
Democratization	References to the communication process being open to all to participate.	Catalysers
Active learning	References to hands-on activities, data collection, making something together, etc.	
Fun/knowledge	References to the need for a fun and engaging experience but at the same time allowing knowledge acquisition.	
Training / common ground	References to everybody involved gaining the necessary knowledge and skills and to establish common ground about the process and outcome.	
Feedback outcome	References to the need for everybody involved knowing what the outcome was, for example, how the data collected was employed.	
Build trust	References to finding strategies to build trust, normally between affected citizens and government officials.	
Break hierarchies	References to finding strategies to break down knowledge hierarches and encouraging everybody to participate to an equal extent.	
Concise / brief information	References to limited space or time for communication and this having to be to the point, for example, in Twitter.	
Misinformation	References to wrong information about flooding and pollution being shared.	Barriers
Exclusivity	References to communication only being inviting or available for some people in society, for example, socially advantaged people.	

All the articles analysed in the systematic review can be found in Table 3.5.

Table 3.5 A list of the 50 articles analysed in the systematic review. Each article is accompanied by the following information: authors, title, country in which the communication was implemented, the environmental threat it relates to, as well as the main communication format it focuses on.

Authors	Title	Country	Environmental Threat	Communication Format
(Aisha et al., 2015)	Exploring the Use of Social Media During the 2014 Flood in Malaysia	Malaysia	Flooding	Social Media
(Al-Saggaf and Simmons, 2015)	Social media in Saudi Arabia: Exploring its use during two natural disasters	Saudi Arabia	Flooding	Social Media
(Bormann et al., 2012)	Adaptation of water management to regional climate change in a coastal region - Hydrological change vs. community perception and strategies	Germany	Flooding	Forum
(Bosschaart, van der Schee and Kuiper, 2016)	Designing a flood-risk education program in the Netherlands	The Netherlands	Flooding	Educational programme
(Bosschaart, van der Schee, Kuiper, et al., 2016)	Evaluating a flood-risk education program in the Netherlands	The Netherlands	Flooding	Educational programme
(Breuer et al., 2017)	Exploring the application of a flood risk management Serious Game platform	Germany	Flooding	Serious games

(Bunce et al., 2012)	Exploring information experience using social media during the 2011 Queensland floods: A pilot study	Australia	Flooding	Social media
(DeForest Hauser et al., 2015)	Passive samplers and community science in regional air quality measurement, education and communication	USA	Air Pollution	Citizen Science
(Demir, 2014)	Interactive web-based hydrological simulation system as an education platform	USA	Flooding	Educational programme
(Elnokaly et al., 2008)	Engaging architects and architectural students in global warming awareness	Egypt	Air Pollution	Educational programmes
(Fedorenko and Sun, 2016)	Microblogging-Based Civic Participation on Environment in China: A Case Study of the PM 2.5 Campaign	China	Air Pollution	Social media
(Felicio et al., 2014)	Stop disasters game experiment with elementary school students in Rio de Janeiro: Building safety culture	Brazil	Flooding	Serious Games
(Fritze and Kray, 2015)	Community and governmental responses to an urban flash flood	Germany	Flooding	Social media

(Jiao et al., 2015)	Application of citizen science risk communication tools in a vulnerable urban community	USA	Air Pollution	Citizen Science
(Kaewkitipong et al., 2012)	Lessons learned from the use of social media in combating a crisis: A case study of 2011 Thailand flooding disaster	Thailand	Flooding	Social media
(Kaewkitipong et al., 2016)	A community-based approach to sharing knowledge before, during, and after crisis events: A case study from Thailand	Thailand	Flooding	Social media
(Kay et al., 2015)	Can Social Media Clear the Air? A Case Study of the Air Pollution Problem in Chinese Cities,	China	Air Pollution	Social Media
(Kongthon et al., 2012)	The role of Twitter during a natural disaster: Case study of 2011 Thai Flood	Thailand	Flooding	Social media
(Kongthon et al., 2014)	The role of social media during a natural disaster: A case study of the 2011 Thai flood	Thailand	Flooding	Social media
(Le Coz et al., 2016)	Crowdsourced data for flood hydrology: Feedback from recent citizen science projects in Argentina,	Argentina, France, New Zealand	Flooding	Citizen Science

	France and New Zealand			
(Leon et al., 2015)	Supporting Local and Traditional Knowledge with Science for Adaptation to Climate Change: Lessons Learned from Participatory Three-Dimensional Modelling in BoeBoe, Solomon Islands	Solomon Islands	Flooding	Forums
(Leong et al., 2015)	ICT-enabled community empowerment in crisis response: Social media in Thailand flooding 2011	Thailand	Flooding	Social media
(Lo et al., 2013)	Reciprocity as deliberative capacity: Lessons from a citizen's deliberation on carbon pricing mechanisms in Australia	Australia	Air Pollution	Forums
(Mackay et al., 2015)	Digital catchment observatories: A platform for engagement and knowledge exchange between catchment scientists, policymakers, and local communities: DIGITAL CATCHMENT	UK	Flooding	Citizen Science

	OBSERVATORY: AIDING STAKEHOLDER ENGAGEMENT			
(Mao and Pan, 2014)	Constructing the cultural repertoire in a natural disaster: The role of social media in the Thailand flood of 2011	Thailand	Flooding	Social media
(McCallum et al., 2016)	Technologies to Support Community Flood Disaster Risk Reduction	China	Flooding	Social Media
(McCormick, 2012)	After the cap: Risk assessment, citizen science and disaster recovery	USA	Air Pollution	Citizen Science
(Moreno Ramírez et al., 2015)	Pollution Prevention through Peer Education: A Community Health Worker and Small and Home-Based Business Initiative on the Arizona-Sonora Border	USA	Air Pollution	Educational programmes
(Naik, 2016)	A crowdsourced sensing system for disaster response: A case study	China	Flooding	Citizen Science
(Ngo et al., 2017)	Why participation matters for air quality studies: risk perceptions, understandings of air	Kenya	Air Pollution	Forums

	pollution and mobilization in a poor neighbourhood in Nairobi, Kenya			
(Rebolledo-Mendez et al., 2009)	Societal impact of a serious game on raising public awareness: The case of FloodSim	UK	Flooding	Serious games
(Rijcken et al., 2012)	'SimDelta'—Inquiry into an Internet-Based Interactive Model for Water Infrastructure Development in The Netherlands	The Netherlands	Flooding	Serious games
(Rizza and Pereira, 2014)	Building a resilient community through social network: Ethical considerations about the 2011 Genoa floods	Italy	Flooding	Social media
(Rodriguez Bermúdez et al., 2015)	ECity: Virtual city environment for engineering problem based learning	Europe	Air Pollution	Serious games
(Roshandel Arbatani et al., 2016)	Effects of Social Media on the Environmental Protection Behaviour of the Public (Case Study: Protecting Zayandeh-Rood River Environment)	Iran	Air Pollution	Social Media

(Rothkrantz, 2016)	Flood control of the smart city Prague	Check Republic	Flooding	Serious games
(Salvati et al., 2016)	Communication strategies to address geo-hydrological risks: the POLARIS web initiative in Italy	Italy	Flooding	Social media
(Santos et al., 2012)	Changing environmental behaviours through smartphone-based augmented experiences., 2012.	Portugal	Air Pollution	Educational programmes
(Savic et al., 2016)	Serious gaming for water systems planning and management	The Netherlands	Flooding	Serious games
(Senaratna et al., 2013)	Natural hazards and climate change in Kenya: Minimizing the impacts on vulnerable communities through early warning systems	Kenya	Flooding	Forums
(Sîrbu et al., 2015)	Participatory patterns in an international air quality monitoring initiative	Belgium, Germany, UK, Italy	Air Pollution	Citizen Science
(St. Denis et al., 2014)	Mastering social media: An analysis of Jefferson County's communications during the 2013 Colorado floods	USA	Flooding	Social media

(Starkey et al., 2017)	Demonstrating the value of community-based ('citizen science') observations for catchment modelling and characterisation	UK	Flooding	Citizen Science
(Wan Hussin et al., 2016)	Knowledge sharing via online social media during flood disaster events: A review	Australia	Flooding	Social media
(Ward et al., 2016)	Air Toxics Under the Big Sky: examining the effectiveness of authentic scientific research on high school students' science skills and interest	USA	Air Pollution	Educational programmes
(Whatmore and Landström, 2011)	Flood apprentices: an exercise in making things public	UK	Flooding	Forums
(Wister et al., 2016)	Emergency population warning about floods by social media	Unspecified	Flooding	Social media
(Xu, 2014)	Communicating the right to know: Social media in the do-it-yourself air quality testing campaign in Chinese cities	China	Air Pollution	Social media
(Yadav and Rahman, 2016)	The social role of social media: the	China	Flooding	Social media

	case of Chennai rains-2015			
(Zhang et al., 2014)	Usage of social media and smartphone application in assessment of physical and psychological well-being of individuals in times of a major air pollution crisis	Southeast Asia	Air Pollution	Social media

3.3 Findings: a comparison of two-way communication formats

This section presents the findings of the systematic review and subsequent content analysis of the selected articles. The findings are organized around the five analysed communication formats: social media, educational programmes, serious games, citizen science, and forums. This section comprises findings in relation to the communication purpose, the direction of communication, the people involved in the communication process, and factors that acted as catalysts for or barriers to communication. In order to give credibility to the interpretation of the data suggested here, quotations from the articles are presented (Bryman, 2012). Before offering an in-depth explanation, a visual comparison of the findings for all five communication formats can be found in Figure 3.2.

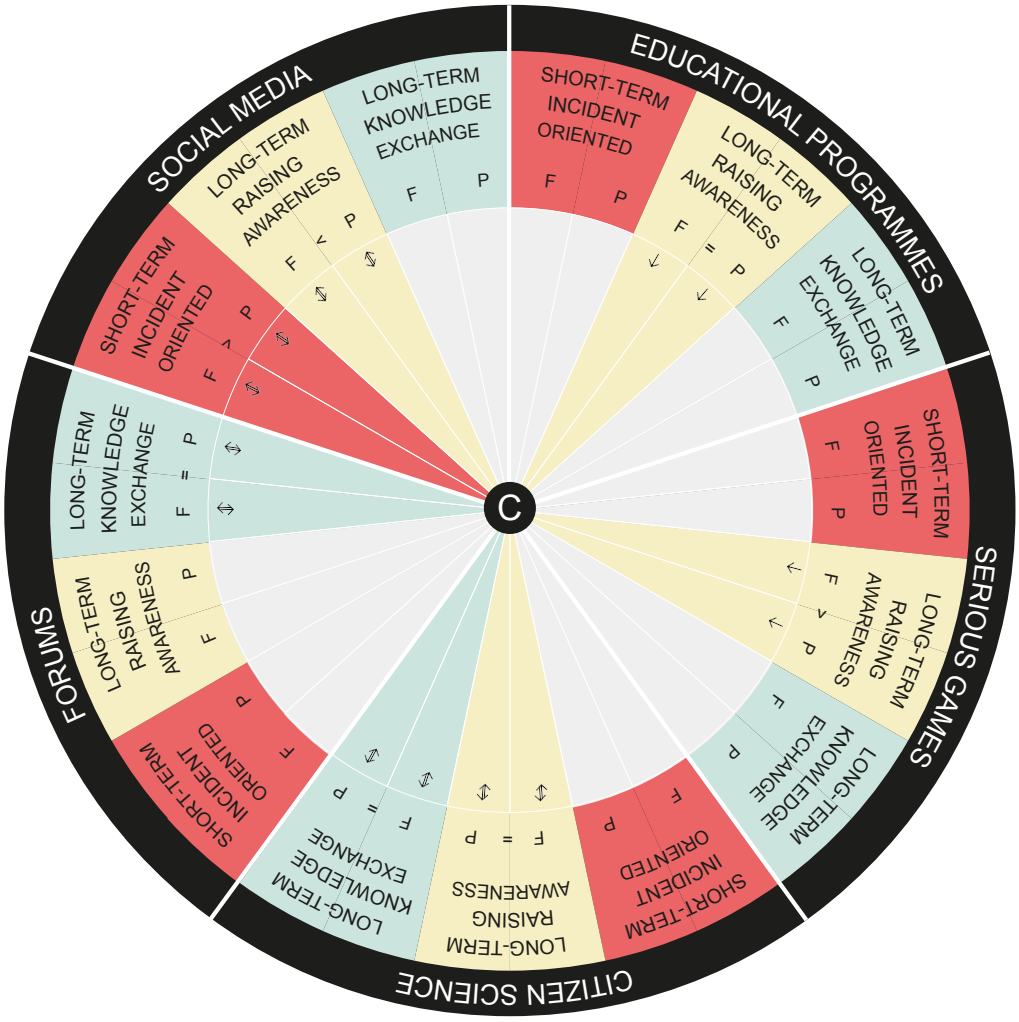


Figure 3.2 A comparison of how social media, educational programmes, serious games, citizen science, and forums can be used for flooding (F) and air pollution (P) risk for a number of academic studies (n=50). It shows whether these formats allow short-term communication, in relation to an ongoing or imminent 'incident'; or whether it is long-term, and for 'raising awareness' or for 'knowledge exchange' purposes. It also shows when examples of air pollution or flooding are more prominent than the other (< , >), and if these communication formats suit both hazards to the same extent (=). The grey zones represent incompatibility of the medium and usage. The arrows represent direction of communication, that is, whether communication is top-down (↓) and initiated by the experts, or if it can also be bottom-up (↕) and initiated by citizens (C) and experts alike.

3.3.1 Social media: incident-related knowledge exchange, response coordination, and awareness raising

Social media can be used for short-term communication in the case of an imminent or ongoing incident, such as flooding (e.g. Bunce et al., 2012) or air pollution crisis (e.g. Zhang et al., 2014). Most examples that involved emergency communication came from flooding and only relatively few from air pollution.

Most often, with the exception of air pollution spikes caused by specific events such as wildfires, air pollution is perceived as an ongoing problem and thus social media is used with a long-term focus (e.g. Fedorenko and Sun, 2016).

The articles showed that when social media is used for short-term communication, it can be done so with three different aims:

Firstly, it can be used to share warnings and information in relation to an incident. For example, during the 2011 Queensland (Australia) floods, the Queensland Police Service used their Facebook page as the main channel for emergency communication, allowing citizens to "access, post and share information about road closures, flood peaks", etc. (Bunce et al., 2012:37). Similarly, during the flooding in Thailand in 2011, social media was used for sharing information and advice on how to behave and what actions to take either from other more experienced citizens or from official sources: "victims shared the photos of their homes and the flood, and the knowledgeable ones uploaded their advice and analysis about the situation" (Leong et al., 2015).

Secondly, social media can also be employed by experts (e.g. government officials or response teams) to communicate with affected citizens and neighbours and collect on-the-ground information regarding the situation during and after a flooding incident, which can help provide a more accurate response to the situation (Rizza and Pereira, 2014). Social media is also used by affected populations to share emotions, and consequently by government officials to observe citizens' physical and psychological well-being during a crisis. During the 2013 Southeast Asian Haze[4], for example, social media allowed the acquisition of information from the general population in this regard, which is key in determining how citizens are coping (Zhang et al., 2014). And thirdly, social media has also proven to be useful for coordinating response to a crisis. For example, it can be

[4] The Southeast Asian haze was a haze crisis from wildfires that affected several countries in Southeast and resulted in high levels of pollution.

used to ask for donations, provide help, or to gather supplies such as temporary accommodation or food (Wan Hussin et al., 2016).

Social media can also be used with a long-term focus, in order to raise awareness about key issues (Roshandel Arbatani et al., 2016). The air pollution movement in China (2011-2012), for instance, used social media for "illustrating the size and impacts of particulate matter in accessible ways" (Fedorenko and Sun, 2016). Social media is also a valuable medium to encourage attitudinal and behavioural change, for example, through sharing adaptation strategies and measures that citizens can adopt to tackle air pollution (Kay et al., 2015). Alternatively, social media can function as an effective platform to encourage debate between experts and community members. In the aftermath of the 2011 Thai flood crisis, social media was used to "share compassionate stories, obtain emotional and physical support from their peers" which helped in the recovery process (Kaewkitipong et al., 2016). Finally, social media can also be employed to campaign in relation to an environmental injustice or problem, fostering collective action, group identity, and a sense of belonging to a community (Xu, 2014). This last usage of social media is especially relevant for countries such as China, where public gatherings of any political nature are prohibited.

Social media facilitates an important three-way process. In social media, downstream approaches from experts to the public coexist with "horizontal interactions" between citizens (Fedorenko and Sun, 2016), alongside an upstream approach were citizens take the lead: "the power previously contained in the hands of government agencies shifts to the people" (Leong et al., 2015:193). In the face of this democratisation of the communication process, different studies highlighted the importance of having a person or a team dedicated to managing social media communications, before, during, and after a crisis. Constant interaction as well as tirelessly responding to questions and comments is key to counteracting misinformation and rumours with real and valid information (Xu, 2014; Wan Hussin et al., 2016). The fact that anyone can post information on social media, and that there is no quality control over what gets posted, can be a limitation inherent to this medium. People receiving incorrect information on how to behave during a flood, or people taking advantage of flood incidents by failing

to pass on donations to victims are two examples of such a limitation (Wan Hussin et al., 2016). On a more practical basis, different studies highlighted the importance of using hashtags to help channel the discussion and the communication efforts to relevant people or to interested parties (St. Denis et al., 2014). Additionally, social media appeared to be a medium for concise and brief information. Twitter in particular has a character limit on Tweets and it is commonplace to find messages containing links to external resources and more detailed information (Ibid.).

3.3.2 Education programmes: awareness raising

If the systematic review found that social media is suitable for short- and long-term communication, then educational programmes were found to be used solely with a long-term focus, namely, to raise awareness or promote a certain behaviour. An educational programme implemented in Arizona, for example, was designed to help home-based and hard-to-reach businesses (e.g. a beauty salon or a printers) in becoming green. The aim was set in helping them transition towards less-toxic substances, as well as in encouraging these professionals to reuse and recycle materials (Moreno Ramírez et al., 2015). In the Netherlands, an educational programme had the aim of improving the understanding of hydrological concepts, and enhancing preparedness intentions of 15-year-old students (Demir, 2014; Bosschaart, van der Schee, Kuiper, et al., 2016).

Educational programmes appeared to follow a downstream approach, meaning that although communication flows from expert to public and vice versa, it is the experts who initiate the communication process, i.e. they are the ones to design, organize, and set up the educational programme. Different studies agreed on the benefits of implementing these programmes with the help of opinion leaders. That is, figures who are respected, perceived as being knowledgeable, and who hold higher levels of trust than, for instance, government officials. Opinion leaders are usually close, or have access, to the community or segment of the population at which the programme is aimed. In the programme implemented in Arizona, female Hispanic community health workers (called 'promotoras') were invited to

run the programme. They possess leadership skills that allow them to effectively influence their community (Moreno Ramírez et al., 2015). They are trusted because they have been trained in public health issues, and because they are "indigenous to the community" (Ibid.). Sometimes, the figure of the opinion leader is interchanged with that of a mediator. In cases when the programme is designed to be implemented in schools, for example, school teachers become mediators, whose job it is to guide the learning (e.g. Bosschaart, van der Schee, Kuiper, et al., 2016), and the experts behind the programme design (e.g. scientists or local governments) remain as an available resource throughout the programme. It is commonplace that these intermediaries receive specific training on how to run the programme. In the case of the 'promotoras', for instance, they received expert training and the necessary materials to provide real-world applications for specific business needs that could translate into positive change (Moreno Ramírez et al., 2015).

Educational programmes are characterized by being highly interactive. This interactivity is sometimes achieved by incorporating virtual reality technology, allowing visualizations, simulations, and animations that allow people to observe, say, different flooding scenarios and their consequences in real-time (Demir, 2014), which would be impossible in real life but are important for learning (e.g. Demir, 2014). In other examples, educational programmes included inquiry-based education where students are provided with equipment and training for air sampling, followed by modules addressing air pollution and health outcomes (Ward et al., 2016). Interactivity was also at the heart of another educational programme based in a school, in which pupils used old newspapers, toys, bottles, etc. from their homes to create an artwork about the concepts of reusing and recycling (Elnokaly et al., 2008). Another key feature of educational programmes is that they often employ real information, such as real-time flood conditions or inundation maps (Demir, 2014). Additionally, the systematic review showed that educational programmes need an element of fun, have to be easy to develop, and that they should offer the appropriate training when more technical knowledge is involved.

3.3.3 Serious games: awareness raising

Just as with educational programmes, serious games are reserved for long-term communication, to increase awareness and understanding, especially around flooding. For example, the aim of the game 'Stop Disasters' is to work with concepts of resilience and resistance (Felicio et al., 2014). Similarly, on 'FloodSim', players must implement a selection of strategies for addressing the risk of flooding based on a pre-defined budget. The game is designed to encourage players to think about: what type of barriers to build, which regions to concentrate on, how much funding to allocate to maintenance, and what warning systems to establish, etc. (Breuer et al., 2017).

Although serious games can be a vehicle for learning and communication in themselves (Felicio et al., 2014), they are sometimes accompanied by discussion and debate and played in classroom settings, where the teacher guides debate, answers questions, and explains concepts (Rodriguez Bermúdez et al., 2015). The usage of serious games goes beyond schools and into informal learning environments such as face-to-face workshops or other public events, where the debate is guided by experts (e.g. scientists). Sometimes, this debate can also take place in a mediated environment such as a blog or a wiki (Ibid.). Although serious games allow two-way interactions between experts and the public, they tend to follow a top-down approach to communication. That is, experts are behind the game design and decide what content and information is included which will, in turn, guide the concepts to be discussed with the public. The United Nations, flood risk management professionals, or scientists in different universities, are some of the people involved in designing serious games who may or may not be involved later in playing the game (e.g. Felicio et al., 2014; Savic et al., 2016). Some of the studies discussed the need for closer collaborations between game developers and knowledge partners so that games more closely fulfil the objective of raising awareness (Rebolledo-Mendez et al., 2009).

Different studies agreed on the importance of having a binomial fun-knowledge combination. That is, the player has to be engaged but acquiring new knowledge

needs to be a requirement for success in the game, i.e. “the game can neither be a simple funny game without any learning, nor only involve difficult concepts without any incentive” (Rodriguez Bermúdez et al., 2015:162). Including random features so that the flow of events cannot be predicted, or offering a diversity of scenarios are some of the strategies employed to keep the player engaged (Ibid.). In order to make sure that the player is learning and taking informed decisions, supporting information can be integrated into the game. For example, in e-City (a game in which players have to develop cities and engage with topics such as energy production, waste management, or pollution), players can get a short explanation of the advantages and disadvantages of possible moves (Rodriguez Bermúdez et al., 2015). From the systematic review, a distinction is that educational programmes are designed to educate but need to have an element of fun, and that serious games are fun but need to educate. Additionally, serious games appeared to be an effective tool for improving understanding as they offer continuous feedback to the player, avoiding the formation of misconceptions (Savic et al., 2016). They also encourage active and experiential learning, allowing players to handle datasets, modify values, and experience simulations which would be impossible or very expensive in real life (Breuer et al., 2017).

3.3.4 Citizen science: awareness raising, and long-term knowledge exchange

Citizen science is also used for long-term communication, appearing to have a broader usage than that of educational programmes and serious games. Citizen science is helpful in raising awareness, but is also employed to facilitate knowledge exchange between experts and the public. For example, 'AirProbe' is a project that aims to raise awareness about air pollution by involving citizens in measuring air pollution in their daily life. The 'AirProbe' project shows that involving citizens in taking measurements can be very effective in producing a positive change (Sîrbu et al., 2015). When citizen science projects aim at raising awareness, they tend to follow a downstream approach, initiated by the experts.

Citizen science projects, however, are also employed to facilitate knowledge exchange between experts and the public, or to complement or challenge expert knowledge. For example, they can be useful in gathering knowledge that would be impossible to collect by experts alone in terms of amount and accessibility. In the case of the Deepwater Horizon oil spill, a citizen science project was developed to allow citizens to contribute "smells, smoke, and other potential risk factors" that they observed, which can in turn be used in decision-making and in complementing scientific measurements (McCormick, 2012:2). Furthermore, as experts and the public often work together in these projects, exchanging knowledge, and discussing scientific data – as opposed to just receiving the outcomes generated by experts alone – these projects have become a means of improving communication and the levels of trust in each other (Thiel et al., 2014; Ngo et al., 2017).

Across all of the citizen science studies that featured in the systematic review, it was observed that those people who suffer the consequences of flooding or air pollution first-hand, are more inclined to participate in such projects. For example, a community that is affected by a flood has more at stake, and therefore, is more inclined to produce citizen scientists and share flood observations (Le Coz et al., 2016). Similarly, residents who live nearer facilities that emit or contain environmental contaminants are more likely to perceive the benefits of participating in a citizen science project aimed at improving their situation (Jiao et al., 2015). Learning about the environment is also another motivation to join citizen science projects, which broadens the spectrum of participants from affected communities to society at large. Schools are sometimes also involved in these projects, integrating them into their science curricula (e.g. Sîrbu et al., 2015). All segments of the population, however, are never equally empowered to participate. For example, projects involving technology, such as social media or Dropbox (Le Coz et al., 2016), will inevitably exclude certain publics.

There are two factors that appear to be essential in citizen science projects. First, most of the studies concurred that the first stage of any of these projects should involve training, and finding common ground between all of the participants. Citizen science projects have a greater chance of fulfilling the established aims if

participants understand: (1) the ultimate aim of the project, (2) how they can contribute to and gain the most the project, (3) how to use the necessary tools appropriately (e.g. air pollution measuring devices), and (4) who to address if they encounter setbacks or if they require further clarifications. Citizen science seems to work better when there is a clear and common goal for every participant involved, and when beneficial outcomes for all are set by all involved (Jiao et al., 2015). Learning about data collection, creating bonds with other community members, or simply having an enjoyable experience, are some of the examples that exceed the most obvious strategic goals usually coupled to these projects (e.g. improving flooding management). Second, most of the studies highlighted the importance of feeding back the results to the group after the completion of the project. Participants should understand the overall impact of the project, and how their contribution fits within it; as well as how the project, the data, and the results are going to be employed (Le Coz et al., 2016).

3.3.5 Forums: long-term knowledge exchange

Discussion forums are used for long-term communication. They are the only medium used solely for knowledge exchange practices, and to bring together local and scientific knowledge. Slightly more examples of forums were found in relation to flooding than to air pollution. In Kenya, for example, a forum was organized by climate experts in order to seek traditional knowledge, and build early flood warning systems: “local farmers are witnesses of their own environment and the first to notice changes and potential risks” and thus, “open dialog is necessary to build climate products that reflect farmers’ needs in terms of warnings” (Senaratna et al., 2013:11). Another air pollution forum, also in Kenya, explored how academics and local residents together could design action points to tackle the air quality issue (Ngo et al., 2017).

Forums can follow a downstream or upstream approach: they are sometimes initiated by experts who believe in the benefits of exploring the ground reality and local knowledge, or by the public who feel threatened and ignored, and consequently take action. Discussion forums are not always representative of the

whole population, as participants usually belong to segments of the population that feel more empowered to participate (e.g. people with higher levels of education). Therefore, community members who participate in these forums are in charge of exchanging any relevant information to the rest of the community. For example, if a forum deals with how to tackle flooding at the community level, the group is then in charge of preparing their community to face a possible flooding event; for example, by organizing meetings and developing training to raise awareness and to prepare the community for any potential evacuation and rescue plans (Senaratna et al., 2013).

Discussion forums are, however, a challenge, and on many occasions they begin with "palpable tension apparent" (Lo et al., 2013:9). This tension can be attributed to a lack of trust in the experts, an incapacity to break down hierarchies of power and to encourage the public to contribute, or to the all-too-often technical language employed by the experts, which distances them from the public. Therefore, some studies have dealt explicitly with how to ease tensions. Consequently, four different strategies were identified here. The first strategy involves experts and the public making something together, the benefits of which are two-fold: making something together works as a *process*, as a facilitatory medium taking the focus away from anything that generates tensions; but it also works as a *product* in order to engage the wider community when this is presented, for example, in an exhibition at a local community centre (Leon et al., 2015). The second strategy is found in one of the forums in the UK, which encouraged participants to bring objects (e.g. maps, photos, satellite images, and even a piece of mouldy carpet) that demonstrated their connection to a flooding event, and which works in highlighting each member's connection to it (Whatmore and Landström, 2011). The third strategy is inspired by citizen science projects, through which the public collect data that later guide the discussion and debate process. For example, asking participants to take readings of personal exposures to Particulate Matter (PM) can be a starting point for later discussions and can aid the non-expert in building and supporting their arguments (Ngo et al., 2017). The fourth and final strategy consists of initiating any forums with an informative session. In one of the forums, for instance, specialists were invited to set the grounds for the debate, sharing information about the scientific, economic, and

political implications of climate change and carbon tax. This was followed by an opportunity to respond to specific queries, and lastly participants were able to design a preferred carbon pricing policy (Lo et al., 2013).

3.3.6 Combining formats

Finally, the five formats (Sections 3.3.1 to 3.3.5) were sometimes combined in order to facilitate their implementation and offer a more positive engagement. A visual representation of the combination of formats can be found in Figure 3.3. For example, sometimes educational programmes and serious games employ social media as a platform to enable discussion (e.g. Rodriguez Bermúdez et al., 2015). Similarly, citizen science initiatives were also found to use social media, not only to facilitate discussion during the project, but also to recruit participants, answer questions, and feed the results back to the group (e.g. Le Coz et al., 2016). In some instances, citizen science-style activities can be developed as part of educational programmes to improve learning (e.g. hands-on activities, place-based learning) (e.g. Ward et al., 2016). Similarly, citizen science can also be employed as a strategy to empower citizens in their discussion and collaboration with the experts (e.g. Ngo et al., 2017).

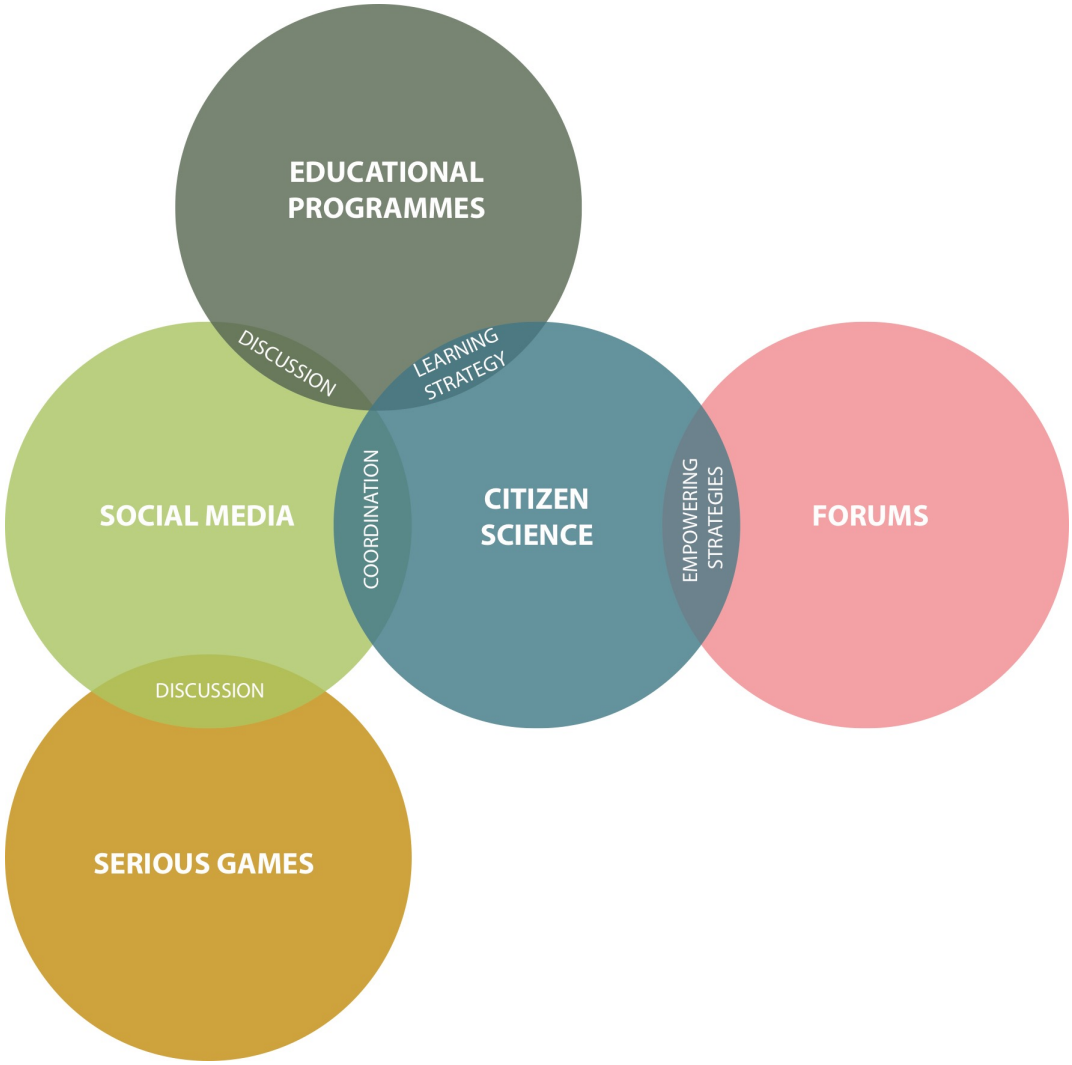


Figure 3.3 A visualization of how social media, serious games, educational programmes, citizen science, and forums have been combined in the studies that were analysed using a systematic review (n=50), and for what purposes.

3.4 Discussion

This systematic review shows that, in the cases analysed here, there is no one-size-fits-all format of communication, and that the suitability of each medium is tied to the communication purpose and the publics that were involved. Emergency communication needs the immediacy and remoteness of social media, whether it is to exchange knowledge about the crisis or to coordinate a response. Expert-public partnerships for knowledge exchange purposes, on the other hand, need face-to-face encounters through forums that allow discussion and negotiation. In these two instances, the public is emotionally invested and can demand upstream approaches to communication where they can initiate the process. Raising

awareness and preparedness of the population can be done through a variety of approaches, i.e. social media, educational programmes, serious games, and citizen science. These communication efforts are always led by experts, following a downstream approach. It is understandable that citizens would rarely demand that they are 'educated', thus the lack of upstream approaches coupled to awareness-raising communication efforts. Returning to the metaphor of the ladder (Arnstein, 1969) in Chapter II (Section 2.2.2), it would seem as if only the highest forms of engagement – represented in the higher rungs – allowed for upstream approaches to two-way communication.

These formats are never suitable for all segments of the population. If social media is the most democratic, it still adds to the digital divide impeding, for example, the participation of older generations. Educational programmes, for instance, target conglomerates such as schools or sector professionals, and hence these require different designs and modes of implementation. Forums and citizen science projects often involve members of affected communities, specifically those who feel confident in meeting face-to-face with experts, and they in turn become the new experts in their communities, entrusted with the responsibilities of communicating with the harder-to-reach groups in that community.

The role of the opinion leaders or mediators is another interesting aspect in two-way communication. This phenomenon seems to be in line with the two-step flow of communication first proposed by Katz and Lazarsfeld (1966). Although this model of communication explains how ideas flow from mass media to opinion leaders, and from them to the sectors of the population that are less active, it can also be used to describe the flow of ideas from the experts to opinion leaders (e.g. community members involved in forums), to those least active segments (e.g. community members who don't feel empowered to participate). This seems to fulfil the purpose of trust issues, but it also might lead to governments, local authorities, or operating authorities passing on responsibility with the danger of destabilising an appropriate balance of responsibility distributed across multiple stakeholders, including the government and affected citizens. According to Johnson and Priest (2008), a shift in responsibility is already occurring: "citizens are being increasingly required to take responsibility for the management of their

own flood risk at both a local community, business and individual household level" (Johnson and Priest, 2008:515). They explain that those at-risk need to assume the responsibility of being more prepared (e.g. household-level adaptation measures), and need to make themselves part of the decision-making in their community (e.g. flood risk management at the community level). In this regard, passing on responsibility in communication and awareness raising too, might contribute further to this phenomenon.

This analysis supports the idea that information alone is insufficient, that communication practices appear to be difficult, and that there is a need for strategies that will break down hierarchies and distract participants from factors that can hinder the encounter. Such hindering factors include previous negative experiences or the lack of trust in each other, and how this is especially accentuated when the people involved in the communication process are emotionally invested (e.g. affected communities). This systematic review shows that a key feature of effective communication or effective usage of the selected communication formats, is here to make flooding and air pollution more accessible and engagement more fun.

In relation to the independent variables, there appear to be few differences in how communication formats are employed across countries, maybe because there are not enough articles per country for differences to emerge. The only distinction is linked to countries such as China, where public meetings of any political nature or ones aimed at questioning the established order are prohibited, and social media thus becomes a mechanism for mobilization. Differences in implementation across threats are more prominent. Social media appears to be a more popular format of communication in relation to flooding than to air pollution. Taking a closer look at social media usage, it appears that flooding requires short-term communication to deal with an imminent or ongoing event, whereas air pollution is best suited to a long-term focus and in relation to improving understanding of the issue, as well as modifying behaviours towards cleaner air. Although educational programmes and serious games appear to be similar in purpose, and share some aspects of their implementation (e.g. a binomial fun/knowledge component), the latter seems to be more popular with regards to flooding. This

might be because of the advantages of serious games in being able to create rich visualizations (flooding scenarios), further highlighting the intangibility of air pollution. Citizen science and forums appear equally suitable for establishing two-way communications for both flooding and air pollution.

From this comparative analysis a series of suggestions for how to establish two-way communication between experts and the public in GM in relation to air pollution can be made:

Information alone is not sufficient and strategies are needed so that engagement becomes more fun. For example, through hands-on activities, such as taking air pollution measurements to truly grasp the severity of the problem; or providing an opportunity to experience (through game playing and simulations) how air pollution levels are affected by increasing the amount of vegetation and reducing the number of cars on the roads.

Two-way communication takes place with targeted groups with different backgrounds and abilities (e.g. technological skills) and these have to be considered when designing such activities.

Segments of the population that are already engaged or empowered can be key. They are more likely to adopt an active role when it comes to engaging with experts or the issue at hand. This means that a two-step-flow of communication can be adopted, where they become the leaders in their communities, for example, in encouraging the adoption of active forms of transport such as cycling.

When it comes to engaging affected citizens who suffer the consequences of environmental issues more severely (e.g. people with asthma, people living next to busy roads, or school children) it is worth considering that they sometimes show lower levels of trust in experts who have not been able to provide a solution or alleviate their situation. Consequently, communication becomes difficult and full of tensions, and strategies are needed to build or restore trust between these two parties. For example, with the help of opinion leaders who are external but trusted (e.g. nurses and school teachers) and can aid communication.

Communication about air pollution is most often long-term and about encouraging behavioural changes. There are only few examples when, similar to the case of flooding, it requires a short-term approach and is incident-oriented. For example, when there are spikes on air pollution caused by meteorological conditions or wildfires putting asthmatics or people who exercise outdoors at risk.

Communication about air pollution is challenging as it aims at changing lifestyles (e.g. cycling instead of driving), which comes at considerable more individual effort than household or community level remediation or adaptation (e.g. installing flood gates).

Communication about air pollution involves less naturally occurring audience-segmentation than communication about flooding. Flooding involves very specific and defined communities often linked to a geographical area (e.g. people living in proximity to a river). Air pollution affects society at large and communication about air pollution should involve audience segmentation strategies.

3.5 Summary

This systematic review offers a comparison of different two-way communication possibilities in relation to flooding and air pollution, two of the major environmental problems threatening GM and other conurbations worldwide. From this comparative analysis a series of recommendations have been made in order to improve the effectiveness of two-way communication between experts and the public. These recommendations include making engagement fun and accessible, knowing the skills and previous experiences of the audience, working together in building or rebuilding trust between groups, combining different formats, and considering the environmental threat as well as the communication purpose.

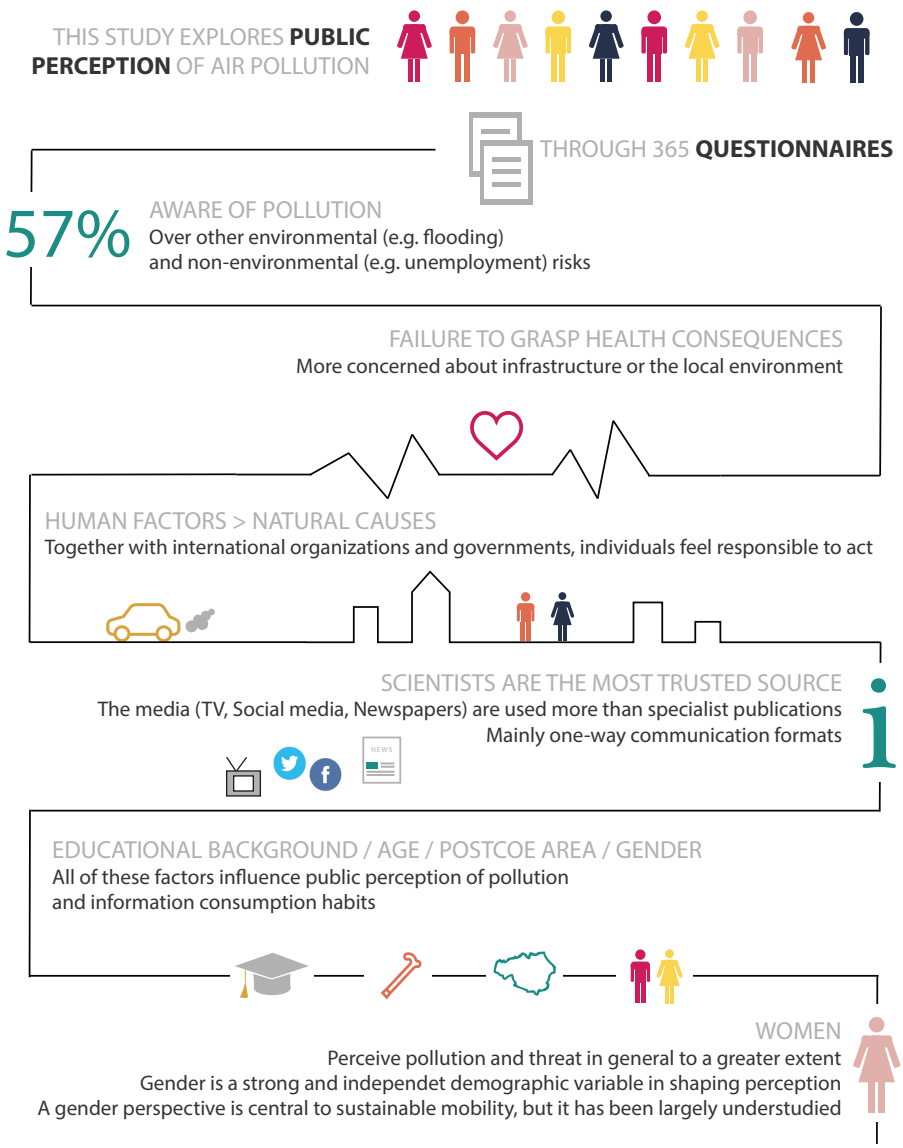
This chapter has built upon the need highlighted in Chapter II (Section 2.2.2. and Section 2.4) to move away from the assumption that the one-way provision of information is suitable for engaging the public as a whole, and to explore instead two-way communication possibilities where the experiences and beliefs of the public are considered. Two-way communication is key for knowledge exchange purposes and promoting valuable local and on-the-ground experiences; but also to raise awareness and encourage positive behaviour *with* the public, that is, based on their needs and values. The chapters to follow complement the exploration of two-way communication possibilities offered in this chapter, with an examination of public perception of air pollution in GM. As discussed in Chapter II (Section 2.2), understanding public perception is central to effective communication, whether through social media or discussion forums.

Chapter IV

Exploring public perception of air pollution and information consumption habits

Infographic

Air pollution and the many publics



Overview

This chapter presents data from a questionnaire with a representative sample of 365 respondents undertaken in Greater Manchester (GM). It explores public perception of environmental hazards and information consumption habits. It also investigates bivariate relationships with the following independent variables: education, age, income, postcode district, and gender. The findings presented in this chapter show that air pollution is a concern for GM residents, more than other environmental (e.g. flooding) and non-environmental (e.g. terrorist attacks or unemployment) threats. However, participants in this study fail to fully grasp the health consequences posed by air pollution. Participants believe that air pollution is mainly an anthropogenic problem, and together with international organizations, and national and local governments, participants acknowledge their responsibility to act. Scientists are highly trusted when it comes to issuing information about environmental issues, unlike the media or local and national governments. Despite this, TV, social media, and newspapers are more widely employed by participants to access information than other more expert sources, such as specialist publications or official websites. Educational level is key in shaping perception in relation to air pollution, trust, and information consumption habits. Age and postcode also appear to exert influence to a lesser extent, and this effect is often intertwined with that of educational level. Gender is an interesting demographic variable: it shapes perception of threat and air pollution, its influence is independent of the above variables, and it is the most complex yet least explored factor in the literature.

The raw questionnaire data that is used in this chapter can be found in the following data repository:

Loroño-Leturiondo, M.; Illingworth, S.; O'Hare, P.; Hoon, S.R.; Cook, S. (2019): Questionnaire findings on Public Perception of Environmental Challenges in Greater Manchester (UK). Centre for Environmental Data Analysis, *17th September 2019.*
http://catalogue.ceda.ac.uk/uuid/c03e7211157649c095b8e4f702b3e737

4.1 Introduction

Although air pollution is a global challenge, experiences of, and contributions to, air pollution are influenced by the local setting. Structural changes and communication efforts that are effective in reducing emissions will have to consider place characteristics as well as the experiences and perceptions of the citizens in that locality. As explained in Chapter II (Section 2.2), the public are generally disengaged and do not take "sufficient" or "radical enough" action (Priest, 2016:25), and it is therefore imperative that more attention is placed on understanding the differences in perception that coexist within a city or conurbation (Bickerstaff, 2004; Bradley, 2009; Kaijser and Kronsell, 2014; Cisneros et al., 2017).

A number of studies have identified different factors that influence how citizens perceive air pollution. As presented in Chapter II (Section 2.2.3), many factors, even those that change across the same city, influence how people perceive air pollution and the impact it can have on their health. These factors are as variable as the amount of greenery or proximity to road networks or clustered industries, as well as the physical management of that place, (e.g. Bickerstaff, 2004; Bickerstaff & Walker, 2001, 2003; Howel, Moffatt, Bush, Dunn, & Prince, 2003; Johnson, 2012; Saksena, 2011; Smallbone, 2012; Xu, Chi, & Zhu, 2017). Other important factors include: living or working in proximity to congested roads or industry, the time spent outdoors, gender, age, level of education, and income (e.g. Badland & Duncan, 2009; Chen et al., 2017; Cisneros et al., 2017; Kim, Yi, & Kim, 2012; Lai & Tao, 2003; Yang & Huang, 2018).

Furthermore, this previous research concurs that social studies dealing with public perception are necessary, and that in the future, greater attention has to be paid to the multiple publics that co-exist in one particular environment, as well that there is a need to further explore groups in society that have traditionally been underexplored or underserved. In light of this, this chapter is concerned with **research question two (RQ2)** presented in Chapter I: how does the public in

Greater Manchester perceive air pollution and access-related information, and what factors affect perception and information consumption habits?

4.2 A public perception questionnaire

This thesis combines quantitative and qualitative research methods for the purpose of answering RQ2 and RQ3. This combination takes place in the form of a sequence, where the quantitative stage guides the qualitative one. This section explains how this combination takes place, and specifically focuses on providing methodological considerations when it comes to data collection and analysis for the quantitative part of the project pertinent to answering RQ2. The qualitative approach will be presented in Chapter V and in relation to RQ3 (i.e. how do women in Greater Manchester conceptualize air pollution and envision a city with clean air?).

4.2.1 Mixed-methods research

Mixed-methods research can be defined as the combination of quantitative and qualitative approaches within a research design in a way that is "mutually illuminating" (Bryman, 2012:628). There are a series of motivations for why researchers combine quantitative and qualitative approaches (Morgan, 1998). In the case of this research these are twofold: first, to draw on the strengths of both methods and offset the weaknesses of one research method in isolation; and second, to provide answers to two different research questions. In this case, a questionnaire as a research method following a quantitative approach will allow the breadth needed to explore the factors that influence public perception of air pollution at a societal level. Similarly, in-depth interviews – guided by the results of the questionnaire – using a qualitative approach will allow the depth required to explore the views of a specific group in society that is key to shaping the future of cleaner air (Morgan, 1998; Bryman, 2012).

Two decisions are key when conducting mixed-method research (Morgan, 1998). The first is in regards to priority, that is, whether the qualitative or the quantitative method is the principal method. The second is related to sequence, i.e. establishing which method comes first (Ibid.). In this thesis, the primary method is the qualitative one, where an in-depth exploration of the views of an important group in society is offered, and the quantitative method is used to set the ground and to give an overview of public perception at a societal level. Therefore, in terms of sequence, the quantitative stage precedes the qualitative one. According to Morgan, (1998), this research corresponds with a preliminary quantitative method in a qualitative study; that is, the knowledge provided by a questionnaire helps the researcher to set up qualitative interviews.

Although mixed-methods research has been widely used, it has also been criticised. This criticism originates from the idea that research approaches are linked to questions of ontology and epistemology or, in other words, questions in relation to the nature of reality and how that reality is accessed by the researcher. These influence the way data are collected, analysed, and reported, and can be fundamentally different in qualitative and quantitative research designs (Guba and Lincoln, 1994; Bryman, 2012). In this regard, this research subscribes to the idea that the division of qualitative and quantitative research is not as clear-cut as is often claimed. Research methods "are not entirely suffused with intellectual inclinations" (Bryman, 2012:19) and they are "much more 'free-floating' in terms of epistemology and ontology than is often supposed" (Bryman, 2012:619). In this thesis, the combination of research methods does not take place at a paradigmatic level, but at a technical one.

What is being combined in this project are the technicalities and affordances (i.e. breadth and depth) of different research methods rather than the paradigms often coupled to them. Both the quantitative and qualitative approaches in this thesis assume that the study of the social world is different to that of the natural world and, therefore, quantitative research is understood as a method that emphasizes numerical data, but that can also generate meaning as qualitative research does (Bryman, 2012). Both approaches in this thesis assume that reality is constructed between people and in relation to one another (constructionism)

(Burr, 2003), that human beings act on the basis of how they interpret reality, and that the way a researcher can access that reality is by providing an interpretation and by grasping the subjective meaning of social action (interpretivism) (Guba and Lincoln, 1994; Bryman, 2012). This thesis rejects paradigms usually linked to quantitative research: that social phenomena or reality have an existence that is independent of social actors (objectivism), and the application of the methods of the natural sciences to the study of social reality (positivism) (Guba and Lincoln, 1994; Bryman, 2012).

In this regard, both the qualitative and quantitative approaches take the same ontological and epistemological stances: social constructionism and interpretivism. Considerations in relation to these are presented in greater detail in Chapter V (Section 5.2.1) together with the qualitative part of the study.

4.2.2 Data collection method: questionnaire

A questionnaire was developed in 2017 and refined iteratively based on the feedback provided by scientific researchers and members of the public. It was hosted by Online Surveys (formerly Bristol Online Surveys) and the data collection took place between 2017 and 2018. The questionnaire was designed to be completed in ten minutes and to gather data in relation to public perception of environmental hazards and information consumption habits. Questions in this regard were followed by a series of demographic questions about postcode, age, gender, educational level, and income. These questions were placed at the end of the questionnaire allowing time to build rapport before participants were asked to reveal private information. This data collection tool received full ethical approval via Manchester Metropolitan University's Academic Ethics Committee (Reference Number: 0660), and the questionnaire can be found in Appendix 4.1.

The main part of the questionnaire was composed of eight questions:

The first question aimed to identify which environmental hazards are perceived by respondents in GM to be most threatening. In exploring which environmental

hazards were of most concern, participants were presented with a list of ten environmental hazards, as well as the options 'none of the above' and 'other'. The environmental hazards listed were deliberately chosen to be wide ranging and not exclusive to the urban environment. They were: 'flooding', 'pollution' (whether this was air, water or noise pollution), 'severe weather (e.g. storms, heatwaves)', 'landslides', 'volcanoes', 'radiation', 'earthquakes', 'tsunamis', 'tornados', and 'wildfires'. Radiation and pollution were left unqualified (i.e. water, air, or noise pollution) to prevent unduly guiding the participants train of thought.

The second question explored what negative impacts were most reported as a consequence of the environmental hazards the participants felt most affected by. This question was inspired by studies concluding that often individuals fail to grasp the individual health consequences of air pollution (Bickerstaff and Walker, 2001; Van den Elshout, 2007; Saksena, 2011; Xu et al., 2017). In finding out what damage participants associated most with environmental hazards, they were presented with the following list, created using the Community Risk Register published by the GMCA (Greater Manchester Resilience Forum, 2015): 'your health', 'your home or business', 'roads and infrastructure (e.g. delay in transport services, school closures)', 'utilities (e.g. electricity, water)', 'your local environment', and 'the local economy (e.g. businesses, tourism, agriculture)', as well as the options 'nothing at all' and 'other'.

The third question was designed to compare how concerning respondents felt these hazards are in relation to other non-environmental hazards. The reason for comparing environmental and non-environmental hazards and exploring relative priorities is found in studies such as Cisneros et al. (2017), El-Zein et al. (2006) and Bord et al. (1998). These studies explain how the real extent to which people are worried about climate change and other environmental threats (e.g. air quality) can only be understood when compared to other phenomena that compete for attention inside an individual's mind. For this question, eight risks (four environmental and four non-environmental) that are relevant for the UK were selected based on the Global Risk Report 2016 (World Economic Forum, 2016). These were: 'floods', 'migration', 'unemployment', 'landslides', 'terrorist attacks', 'volcanoes', 'cyberattacks', and 'pollution'. In order to gather data in relation to

the level of threat perceived, participants were asked to choose an option from the following categorical 5-point Likert–type scale: 'not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous'.

The fourth question was designed to gather data in relation to the extent to which participants believe environmental hazards are caused by natural forces or human activity. Participants were presented with a 5-point Likert-type scale to measure whether they thought environmental hazards were caused by natural forces (1), human activity (5), or a combination of both (3). The fifth question was designed to explore responsibility and asked participants to choose who they thought was most responsible to manage or act in response to environmental hazards. Participants were given a list to choose from and were asked to prioritise by limiting their answers to three. This list was created in collaboration with the Association of Greater Manchester Authorities (AGMA). It comprised: 'international organisations (e.g. The United Nations)', 'the national government (i.e. the UK government)', 'local governments (i.e. your city council)', 'business and industry', 'scientists and researchers', 'environmental organisations', 'individuals', as well as the option 'other'. Both these questions were included as different studies show how perceived responsibility for emissions and tackling air pollution (and climate change) can be translated into whether the necessary positive behaviours are adopted (Bickerstaff and Walker, 2002; Whitmarsh, 2005).

Question six was designed to explore information consumption in relation to environmental hazards. In this regard, participants were asked to state who they got information about environmental hazards from: 'family and friends', 'scientists from related fields', 'the government', 'local organizations', 'the media', 'environmental organizations', as well as the option 'other'. Question seven was related to the previous questions and asked respondents how much they trusted these groups with a categorical 5-point Likert scale: 'not at all', 'not very much', 'I don't know', 'fairly', and 'completely'. These questions were inspired by studies explaining how the source of information, as well as the level of trust placed in a source, can influence how the message is perceived and understood (Rogers, 2003; Bickerstaff, 2004; Bultitude, 2011; Priest, 2016).

The aim of question eight was to identify which media participants rely on the most in order to get information about environmental hazards. When asked about preferred media, participants were presented with the following list: 'social media', 'newspapers', 'radio', 'TV', 'games', 'special events (e.g. science festivals, exhibitions)', 'leaflets (e.g. mailbox)', 'specialist publications (e.g. reports, academic journals)', 'official websites (e.g. Met Office)', as well as the option 'other'. This question was inspired by studies exploring the effectiveness of two-way communication and innovative communication formats, and to ascertain the extent to which these are being employed by survey respondents (Abt, 2002; Rodriguez Bermúdez et al., 2015).

These eight questions were followed by five demographic questions to gather data in relation to: level of education (no formal qualifications, GCSE/ O-Level, A-Level/ Higher/ BTEC, Vocational/ NVQ, degree or equivalent, postgraduate qualifications), age (<18, 18-24, 25-34, 35-49, 50-80, >80), household annual income (> £55,000, £45,000 - £55,000, £35,000 - £44,999, £25,000 - £34,999, £15,000 - £24,999, < £15,000), postcode areas (M, SK, BL, OL, WN, and WA) (see Figure 4.1 for a representation of these areas on a map), and gender (female and male). Although the question about gender was framed as an open-ended question, only two participants (0.5%) responded with something other than this binary classification, and 11 participants (3%) left that question (and other demographic questions) unanswered. Therefore, other gender options have been excluded for the analysis and reporting of results. Full (six character) UK postal codes can be employed to achieve much finer spatial resolution down to small clusters of dwellings at street and building level. This, however, can result in respondents perceiving that their privacy and anonymity could be compromised and thus they might well withhold their full postal code. Hence only the first three characters were requested or used to identify their broad location within GM. Even then a number of participants only agreed to provide the first two characters (which are the letters employed in this study M, SK, BL, OL, WN, and WA). These five demographic questions were chosen because they have all proven across different studies to show some effect – even if at times contradictory ones (Flynn et al., 1994; Bickerstaff and Walker, 2001; Howel et al., 2003; Lai and Tao, 2003; Lepp and Gibson, 2003; Kahan et al., 2007; Badland and Duncan, 2009; Saksena,

2011; Kim et al., 2012; Becken et al., 2017; Chen et al., 2017; Cisneros et al., 2017; Xu et al., 2017; Yang and Huang, 2018).

The questionnaire was mainly conducted at street level giving rise to discussion with participants based on, and beyond, the questionnaire. It was also emphasized that participants had to respond to the questions based on their own personal opinion and experience, and not by thinking at a societal level. The data collection was performed following appropriate ethical procedures of informed consent (Appendix 4.2), explaining the purpose of the study to all participants, and answering any questions they had. Interviewees were made aware that they could withdraw from the study at any stage. The data collection process entailed strict confidentiality but was not entirely anonymous as participants were asked to provide contact details if the wished to be invited to participate in interviews (for the qualitative part of the study presented in Chapter V). Once data collection was complete, data was anonymised and numbers were assigned to participants for data analysis purposes. With the approval of Manchester Metropolitan University's Academic Ethics Committee, the anonymised data was stored in a university server, which was password protected during the data collection and analysis processes, and was then made publicly available through the Centre for Environmental Data Analysis (CEDA) data repository (Loroño-Leturiondo et al., 2019b).

The researcher's positionality, that is, how the researcher presents the self, influences how participants react to the study and respond to the questions asked. In this regard, a researcher can be perceived to hold a position of privilege and power (Savin-Baden, 2010; Corlett and Mavin, 2018). A researcher representing a university could influence, for example, how participants respond to notions of trust in relation to scientists (question six). During data collection, and when approaching participants at street level, it was made explicit how this thesis was a student project which facilitated being dissociated from the figure of the expert and a position of power.

Before the data collection began, a pilot study was conducted to ensure that questions were well structured and that the questionnaire allowed for collection

of the appropriate type and form of data (Fink, 2003; Bryman, 2012). The pilot study took place with a total of twenty participants and in two stages: first with the close network of friends and colleagues and later with the general public.

Results of the pilot study suggested changes were necessary in some of the questions. Originally, in exploring which environmental hazards were of most concern (question one), participants were presented with an open-ended question. However, through piloting the questionnaire it became clear that this question was too complex or vague for many participants, and responses had to be prompted on most occasions. Subsequently, this was converted into a multiple-choice question. Similarly, in the question dealing with preferred media (question eight) various participants suggested 'official websites' in the 'other' field, so this was then incorporated into the multiple-choice list.

4.2.3 Sampling: stratified random sampling

The questionnaire had 365 respondents based in GM. As the total population of GM was 2.8 million in 2011 (2011 Census), this sample size is sufficient to enable a 95% confidence level when assigning an attitude or response to a particular proportion of respondents. The size of the sample needed was calculated with the Excel sample size calculator developed by Fernández (1996). The resulting sample size is comparable to that of other studies concerned with public perception (e.g. Becken et al., 2017; Bickerstaff and Walker, 2001; Bush et al., 2001; Guo and Li, 2018; Lepp and Gibson, 2003; Lorenzoni and Hulme, 2009; Smallbone, 2012; Whitmarsh, 2009).

The recruitment of participants was conducted in two different stages: first, online, using different social media platforms (e.g. Greater Manchester Combined Authorities' Twitter profile), but mostly at street level in all six postcode districts of GM to target participants that would otherwise not be reached through an online questionnaire (e.g. elderly citizens). Participants were recruited following a stratified random sampling technique (Bryman, 2012) to ensure that the number of participants recruited in each postcode district was proportional to the number

of inhabitants in GM, as this would permit conducting a statistical analysis based on postcode area. An ongoing analysis of the characteristics of the sample was performed to allow time to correct for misrepresentations while still in the field. Although gender and age were, in most cases, easy to correct (for example by reaching out to the age groups that were underrepresented in the sample), income or educational background were more difficult to surmise. When comparing our sample with the most recent census data (2011) (Figure 4.1), we find it to be mostly representative of the demographic profile of the population of GM. Our sample differs in so far as the average annual income per household per annum (£31,000) is 11% lower than that of the census (£35,000). There is also an overrepresentation of people holding degrees and postgraduate qualifications (42.9% compared to 23.9%), as well as an underrepresentation of people with no formal qualifications (11.5% compared to 25.2%). Citizens over 80 years old are also underrepresented (1.4% compared to 6.9%). This representation issue is not unique to this work. Studies analysing which socio-demographic groups are more likely to respond to questionnaires find that people that had received more formal education, as well as those with higher income and status, show higher response rates, whereas oldest age groups are less likely to participate (Suchman and McCandless, 1940; Green, 1996).

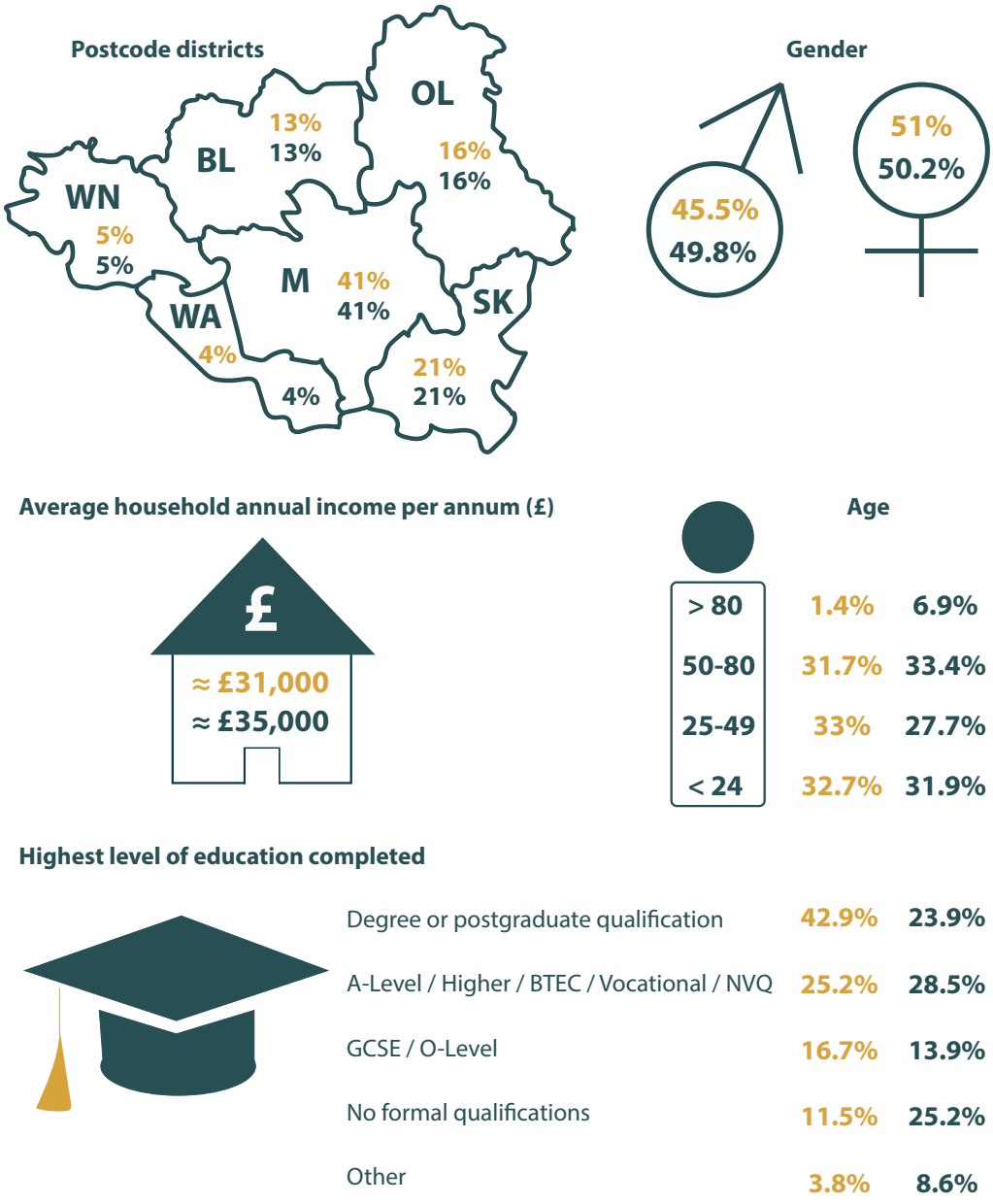


Figure 4.1 Characteristics of the sample (yellow/light) in relation to 2011 census data (green/dark) based on: postcode districts, gender, average annual household income per annum (£), age, and highest level of education completed.

4.2.4 Data analysis: chi-squared and bivariate relationships

This study relied on inferential statistics to generalize the findings of a sample to the general population of GM. That is, to ascertain whether differences between groups in the sample are indeed a result of existing differences (Allua and Thompson, 2009). Inferential statistics can be employed to evaluate differences, examine relationships, and make predictions (Allua and Thompson, 2009). In the case at hand, the aim of the statistical analysis was to examine relationships.

The questionnaire data were analysed statistically using R – a software platform for statistical computing widely employed for data analysis, and bivariate relationships were investigated using the chi square test of significance. Bivariate analysis concerns the exploration of two variables at a time in order to ascertain whether or not they are related (Bryman, 2012). In this regard, all eight questions (dependent variables) presented in the section above were analysed in relation to all five demographic questions (independent variables): level of education, gender, income, postcode area, and age. A bivariate analysis was selected as the interest is not in the relationship between two or more independent variables, but on exploring a single dependent variable (e.g. whether participants feel affected by pollution) and multiple groups of participants (e.g. male and females) (Field et al., 2012).

The chi-squared test calculates the disparity between the observed and expected frequencies in a contingency table. It enables the decision to be made as to whether or not the null hypothesis that the data are independent can be rejected, conventionally if the p-value is < 0.05 (Howitt and Cramer, 2014). This test is appropriate for these data because it is a non-parametric test for variables that do not have a normal distribution. It is suitable for ordinal and nominal variables when there are multiple categories in each variable and when the number of frequencies equals the number of participants (Allua and Thompson, 2009; Howitt and Cramer, 2014).

4.2.5 Assessing quantitative research: validity and reliability

Reliability and validity are two widely employed criteria for the evaluation of quantitative studies in social research such as those employing questionnaires (Fink, 2003; Bryman, 2012). Fink (2003:47) asserts “a reliable survey instrument is consistent; a valid one is accurate”.

Reliability is about the stability of a measure, that is, whether all the items in the questionnaire are measuring what is being studied (i.e. public perception of environmental hazards and information consumption). Cronbach’s

coefficient alpha is widely used to assist in the identification of relationships between the items in a questionnaire (Fink, 2003; Tavakol and Dennick, 2011; Bryman, 2012). This coefficient varies between 0 (no internal reliability) and 1 (perfect internal reliability) and there is agreement that anything above 0.70 denotes a satisfactory level of reliability (Ibid.). In this study, Cronbach's alpha was applied to the Likert-type scale questions (such as question three in the questionnaire) using Excel and a score of 0.72 was obtained. Cronbach's alpha was calculated as in Equation 4.1 (DeVellis, 1991):

Number of items in the questionnaire that correspond with Likert-type scale questions **15**

Sum of the variance (var.p) of each of the items across all the respondents **20.2**

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K}\sigma_{Y_i}^2}{\sigma_X^2}\right) = \mathbf{0.72} \qquad (4.1)$$

Variance (var.p) of total scores of all the respondents **61.1**

Reliability also tests whether participants understand the questionnaire correctly. In this regard, a pilot study is imperative in designing a questionnaire that can be verified as being reliable (Fink, 2003; Bryman, 2012).

Validity in this study is understood in two different ways. Firstly, it refers to the representativeness of the sample (external validity); that is, whether findings apply to the society that the study aims to study or just to the specific number of individuals who participated in the questionnaire (Bryman, 2012). And secondly, it refers to the naturalness of the research approach (ecological validity), i.e. whether findings are applicable to "people's everyday natural social settings" (Bryman, 2012:711). External validity is strong when random sampling methods have been selected, such as in this study where a stratified random sampling technique was utilized. In terms of ecological validity, the more a researcher intervenes (e.g. the use of special rooms to conduct questionnaires) the more validity is compromised. Self-completion questionnaires are by definition

disruptive of the natural environment, but in trying to keep the process as natural as possible these mostly took place in the street rather than in isolated or intimidating venue conditions (i.e. in a research room).

4.3 Findings: public perception and information consumption habits

This section contains the findings of the questionnaire. Firstly, findings are presented for the total population of GM in relation to perceived threat and damage, agency and responsibility, and information consumption habits and trust. Secondly, findings are examined according to the following five independent variables: education, age, income, postcode district, and gender.

4.3.1 Perceived threat of environmental and non-environmental hazards.

When asked what environmental hazards participants felt they were affected by (multiple answers permitted), 'pollution' was the most reported (57.3%) (Figure 4.2). It is worth noting that it was up to participants to determine what 'affected' meant. As most of the questionnaires were conducted at street level and in conversation, it was discussed with participants what form of pollution they were thinking about. In these conversations it became clear that participants thought of pollution as air pollution, over other forms such as noise or water pollution. For example, an often-repeated remark was that although air pollution is not as visible as it was 'in the past' or 'in the old days' based on experience, photographs or documentaries, it is still 'there' and it is still a problem. There was also a significant number of participants who felt affected by 'severe weather' (41.9%). This, however, has been excluded from the study as, in conversation with participants while completing the questionnaire, the term appeared to have been misunderstood by participants and confused with the characteristically wet climate of GM. For example, participants would refer to the periodicity of rain in

Manchester, highlighting how inconvenient it is rather than emphasising the disruptions caused by it. Similarly, participants only focused on the wet climate, failing to refer to other meteorologically dangerous phenomena, such as heatwaves. 'Flooding' was the next most reported environmental hazard (37.5%), and this was followed by those participants who did not feel affected by any of the given environmental hazards: 'none of these' (18.9%). The remaining options were selected by less than 5% of respondents, namely: 'radiation' (3%), 'volcanoes' (1.4%), 'earthquakes' (1.1%), 'wildfires' (0.8%), 'landslides' (0.5%), 'tornados' (0.3%), and 'tsunamis' (0.3%).

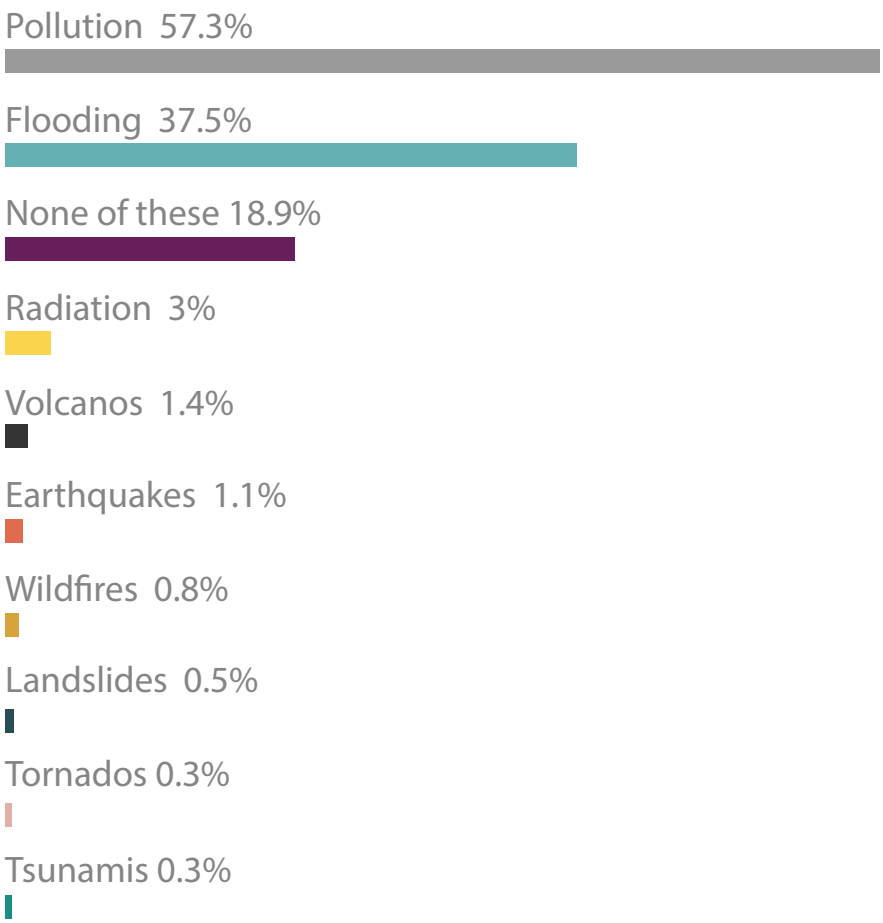


Figure 4.2 Percentage of questionnaire respondents who reported being affected by different environmental hazards (n = 365).

When asked about how threatening these environmental hazards were in relation to the other non-environmental hazards (Figure 4.3), participants reported being most concerned about 'pollution' (69.4%), followed by 'terrorist attacks' (60.3%), 'cyberattacks' (51.7%), 'unemployment' (33.6%), 'flooding' (29%), 'migration' (13.1%), 'landslides' (10.1%), and 'volcanoes' (9.3%). These percentages were

calculated by adding the scores of the categorical 5-point Likert-type scale 'fairly' and 'very' dangerous. When looking at the responses across the categorical 5-point Likert-type scale ('not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous'), there is strong agreement between participants in relation to how threatening these hazards are when it comes to 'volcanoes', 'landslides', and 'migration'; fair agreement in relation to 'pollution', less agreement in relation to 'flooding', 'terrorist attacks' and 'cyberattacks', and very little agreement in relation to 'unemployment'.

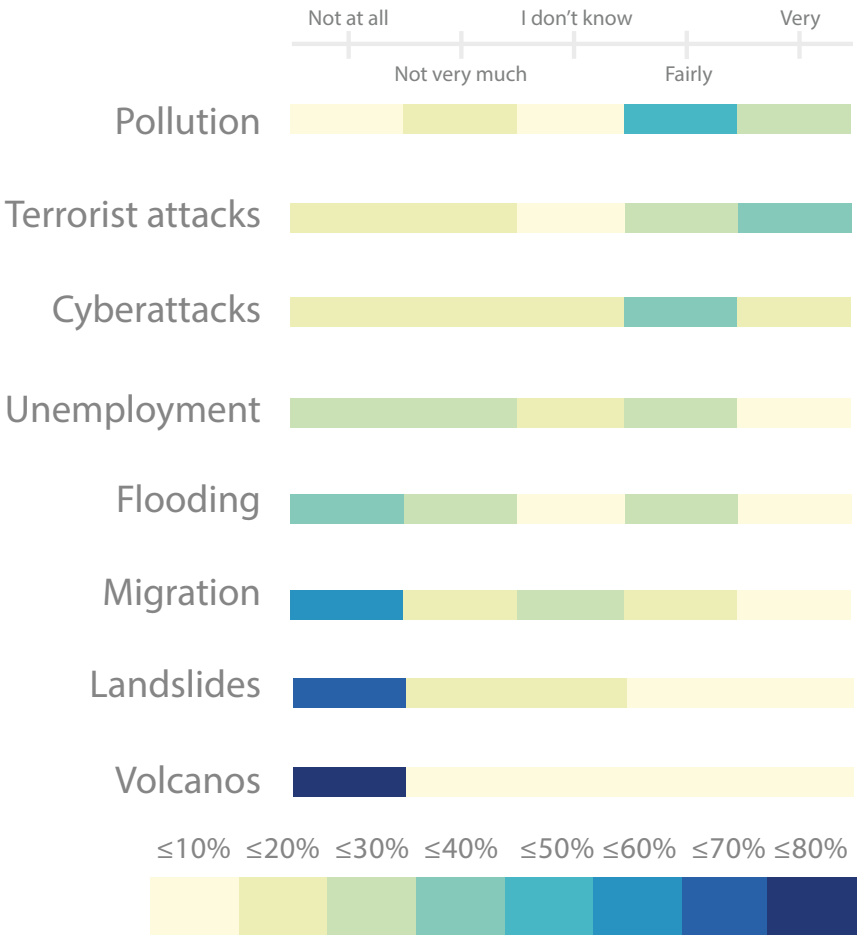


Figure 4.3 Perceptions of threat posed by four environmental and four non-environmental hazards as reported by questionnaire respondents, as well as how united (dark) or divided (light) the opinion was found to be (n = 365).

When looking at independent variables in relation to how dangerous pollution and other threats were perceived to be, statistically significant differences (p-value < 0.05) were found in relation to educational level, postcode area, and gender. For example, educational level (p-value < 0.01) affected how dangerous pollution was perceived to be. Respondents with higher levels of education reported pollution

to be a bigger threat. As can be seen in Table 4.1, 77.4% of respondents holding postgraduate qualifications, and 73.4% holding university degrees, reported feeling pollution as being 'fairly' or 'very' dangerous, whereas only 68.2% with no formal qualifications did so.

Table 4.1 Percentage of respondents by educational level perceiving pollution as being 'fairly' or 'very' dangerous in the categorical 5-point Likert-type scale ('not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous') (n = 253).

Education	Pollution being fairly or very dangerous
No formal qualifications	68.2
GCSE/ O-Level	62.3
A-Level/ Higher/ BTEC	63.1
Vocational/ NVQ	59.3
Degree or equivalent	73.4
Postgraduate qualification	77.4
p-value < 0.01	

Statistically significant differences also appeared in relation to how dangerous pollution was perceived to be in different postcode areas (p-value < 0.001). When more than one independent variable appeared to influence a dependent variable, the connection between these independent variables was explored further. In this case, as the independent variables educational level and postcode were related (p-value < 0.001), it was explored whether the differences in perception across postcode areas corresponded with differences in educational level in these areas. In order to be able to conduct this comparison it was necessary to attribute a level of education to each category (i.e. to each postcode area). For this purpose, an average score was calculated based on the educational level of participants in that category, where 1 is no qualifications and 6 is postgraduate qualification (see second column in Table 4.2). As can be seen in Table 4.2, WA was the postcode area where participants had received more formal academic education, followed by postcode area M. Although there was a large number of respondents reporting that pollution is 'fairly' or 'very' dangerous in M (76.7%), only 40% of participants in WA reported this. Therefore, it could be concluded that postcode area shaped perception differently and that this was not purely an educational level effect. Respondents in larger or more populated postcodes areas perceived pollution to be more threatening than those in smaller and less populated areas.

Table 4.2 Percentage of respondents by postcode area perceiving pollution as being 'fairly' or 'very' dangerous in the categorical 5-point Likert-type scale ('not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous'), as well as the relation to educational level of respondents in that area. The level of education has been calculated by creating an average score where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification' (n = 253).

Postcode	Education	Pollution being fairly or very dangerous
M	4.4	76.7
SK	3.5	75.3
BL	3.6	70.2
OL	3.2	51.7
WN	3.7	61.1
WA	4.6	40.0
p-value (postcode/pollution) < 0.001 p-value (postcode/education) < 0.001		

When looking at the concept of threat in general (i.e. the addition of responses for all eight environmental and non-environmental hazards), statistically significant differences were found in relation to gender (p-value < 0.005). That is, when asked to state how threatening the eight different hazards were, the proportion of women was higher for the categories 'fairly' (23.2% females and 21.2% males) and 'very' (13.4% females and 10.7% males), and lower for the categories 'not at all' (34.5% females and 39.2% males) and 'not very much' (16.5% females and 18.1% males). Gender was not related to the variables educational level (p-value > 0.05) or postcode (p-value > 0.05), which were the other two independent variables affecting how dangerous pollution was perceived to be, and the relation between perception and gender could therefore be established.

Table 4.3 Percentage of respondents by gender perceiving threat (for all eight environmental and non-environmental hazards combined) as being 'not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous' (n = 352).

		Not at all (%)	Not very much (%)	I don't know (%)	Fairly (%)	Very (%)
Gender	M	39.2	18.1	10.8	21.2	10.7
	F	34.5	16.5	12.3	23.2	13.4
	p-value < 0.005					

Differences of perception of the threat posed by pollution between male and females were found to be statistically significant for postcode area M (p-value < 0.05). In M, considerably more females than males reported feeling 'fairly' threatened (59.7% females and 45.6% males) and fewer females reported feeling 'not very much' threatened by pollution (11.7% female and 19.1% males).

Table 4.4 Percentage of respondents by gender for the postcode area M perceiving pollution as being 'not dangerous', 'somewhat dangerous', 'I don't know', 'fairly dangerous', and 'very dangerous' (n = 150).

Postcode	Gender	Not at all (%)	Not very much (%)	I don't know (%)	Fairly (%)	Very (%)
M	F	3.9	11.7	1.3	59.7	23.4
	M	0.0	19.1	13.2	45.6	22.1
p-value < 0.05						

4.3.2 Perceived damage

When asked about the damage caused by all the environmental hazards (i.e. flooding, pollution, severe weather, landslides, volcanoes, radiation, earthquakes, tsunamis, tornados, and wildfires) questionnaire respondents reported (Figure 4.4): 'roads and infrastructure' (59.7%) to be the most damaged, followed by 'local environment' (39.7%), 'utilities' (25.5%), 'health' (23.3%), 'the local economy' (22.2%), 'home or business' (21.6%), and 'nothing at all' (18.1%).

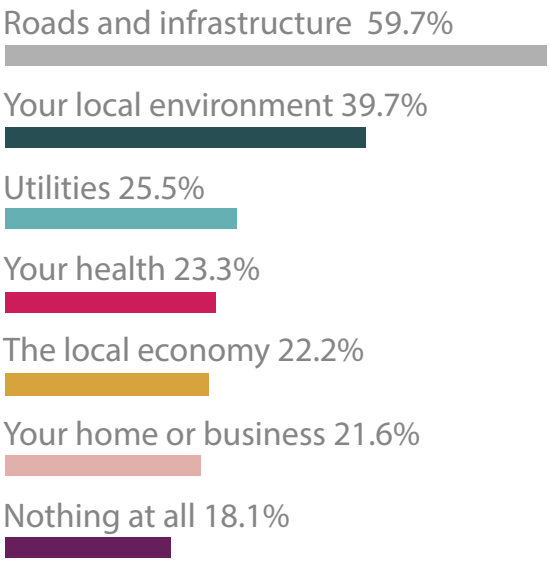


Figure 4.4 Perceived damage caused by the environmental hazards that questionnaire participants felt affected by (from the list of eight environmental hazards) (n = 365).

Statistically significant differences were not found in relation to how damage is perceived based on postcode area, educational background, income, age, and gender.

4.3.3 Perceived agency and responsibility

When asked about whether environmental hazards are caused by human activity or natural forces, 43.8% of respondents reported an even combination of both (3 in the 5-point Likert scale type question) (Figure 4.5). The second most reported option (29% of respondents) was 2 in the 5-point Likert scale type question – that is a combination of both but where human activity predominates.

This pattern was accentuated when looking at the responses of only those participants who reported feeling affected by pollution. Figure 4.5 shows that in this case, an even combination of natural forces and human activity (3 in the 5-point Likert scale type question) was only reported by 35.4% of participants (in contrast to 43.8% in the general case), and a combination where human activity predominates (2 in the 5-point Likert in the scale) was selected by 36.4% of respondents (in contrast to 29% in the general case). In other words, participants perceived environmental hazards to be caused by a combination of human activity and natural forces where human activity was slightly more responsible, especially in the case of participants who reported being affected by pollution.

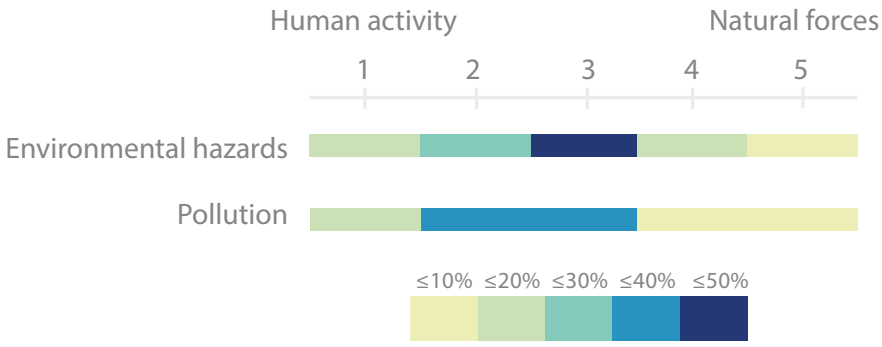


Figure 4.5 Perception of whether environmental hazards are caused by human activity (1), natural forces (5) or by a combination of both (2,3,4). As well as perception by questionnaire respondents who reported feeling affected by pollution. The graph shows how united (dark) or divided (light) the observed opinion was found to be (n = 365).

When asked about who is most responsible to manage or act in the face of environmental hazards (a maximum of three responses were allowed in order to make participants prioritise) (Figure 4.6), the most reported group was the 'national government' (25.9%), followed by the 'local government' (19.7%), 'international organizations' (14.9%), and 'individuals' (12.9%). This shows how

participants believed they are responsible to a greater extent than 'business and industry' (11.1%), 'environmental organizations' (9.6%), or 'scientists and researchers' (5.9%).

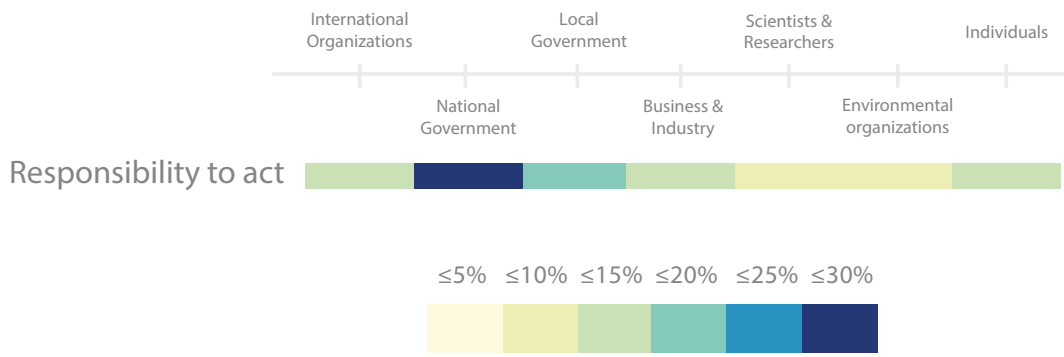


Figure 4.6 Perceived responsibility of different actors to act in the face of or manage environmental hazards. The graph shows how united (dark) or divided (light) the observed opinion was found to be (n = 365).

Statistically significant differences were not found in relation to agency and responsibility based on postcode area, educational background, income, age, and gender.

4.3.4 Information consumption and perceived trust in different groups

When participants were asked about what sources they use to get information about environmental issues (multiple answers allowed) (Figure 4.7), the most reported source was 'the media' (80% of respondents). This was followed by: 'environmental organizations' (23%), 'friends and family' (21.1%), 'scientists' (20%), 'the government' (19.2%), and 'local organizations' (18.9%). Participants were also asked about how much they trusted these same groups when they talk about environmental issues (Figure 4.7). Although 'the media' was the preferred source, 'environmental organizations' and 'scientists' were trusted to a greater extent. When combining the percentages of trusting a source 'fairly' or 'completely', 'environmental organizations' and 'scientists' were trusted by 78.9% and 78.1% of respondents respectively. These are followed by 'family and friends' (54.3%), 'local organizations' (50.7%), 'the media' (35.6%), and 'the government' (32.6%).

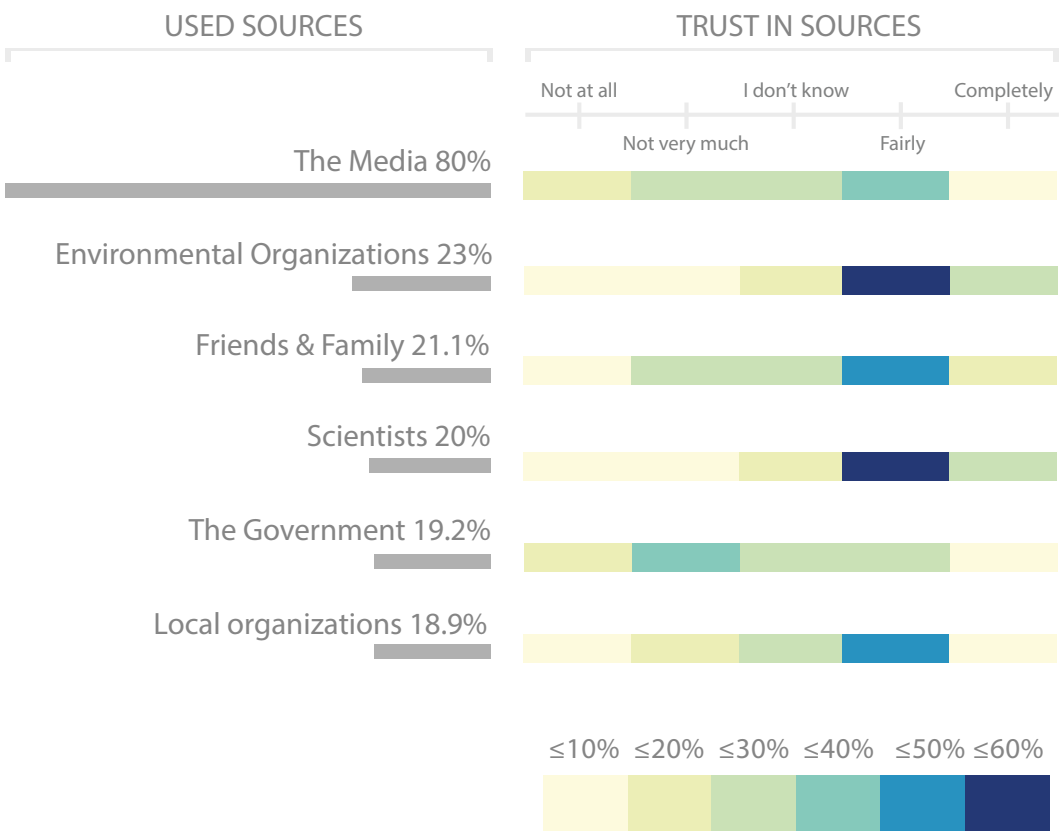


Figure 4.7 Preferred information sources as reported by questionnaire participants, as well as how much these sources are trusted when they talk about environmental issues. The graph shows how united (dark) or divided (light) the observed opinion was found to be when it comes to perceived levels of trust (n = 365).

When asked about preferred media to access information about environmental hazards (multiple answers allowed) (Figure 4.8), the most popular response was 'TV' (selected by 66% of respondents), followed by 'social media' (65.5%), 'newspapers' (55.1%), 'radio' (42.7%), 'official websites' (34%), 'special publications' (17%), 'leaflets' (13.4%), 'special events' (8.8%), and 'games' (0.5%).

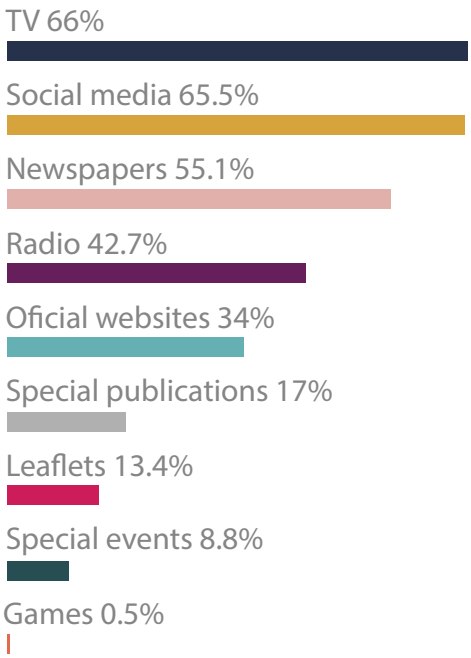


Figure 4.8 Preferred media for accessing information about environmental hazards as reported by questionnaire respondents (n = 365).

When looking at independent variables in relation to information consumption and trust, statistically significant differences (p-value < 0.05) were found in relation to educational level, postcode area, age, and gender.

When it comes to relying on scientists as a source of information, differences were observed in relation to educational level (p-value < 0.001). The higher the level of formal education that respondents had obtained, the more they relied on scientists for information. As can be seen in Table 4.5, 33.9% of respondents holding postgraduate qualifications reported acquiring information from 'scientists', while only 9.1% of people with no formal qualifications reported using this source. A similar pattern was observed when it comes to educational level and trust in scientists (p-value < 0.001). As can be seen in Table 4.5, 95.2% of respondents holding postgraduate qualifications reported trusting 'scientists' when they talk about environmentally related issues, but only 63.6% respondents with no formal qualifications did so.

Table 4.5 Percentage of respondents by educational level reporting relying on 'scientists' for information in relation to environmental hazards (n=73), and to trust 'scientists' 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely') (n = 285).

Education	Rely on scientists	Trust scientists fairly or completely
No formal qualifications	9.1	63.6
GCSE/ O-Level	3.3	67.2
A-Level/ Higher/ BTEC	24.6	63.1
Vocational/ NVQ	14.8	81.5
Degree or equivalent	20.2	84.0
Postgraduate qualification	33.9	95.2
p-value (education/rely) < 0.001 p-value (education/trust) < 0.001		

Differences were also observed in relation to relying on scientists for information across postcode areas (p-value < 0.001). As the variables postcode area and educational level were related (p-value < 0.001) an analysis was conducted to ascertain whether the differences in postcode corresponded with differences in level of education. As can be seen in Table 4.6, WA was the postcode area where participants had the highest levels of education, followed by postcode area M. Although respondents in M relied on 'scientists' the most (30.7%), only 6.7% of respondents did so in WA. Therefore, it would appear that postcode area had its own effect, and respondents in larger or more populated postcodes areas relied on scientists to a greater extent than respondents in smaller and less populated areas.

Table 4.6 Percentage of respondents by postcode area reporting relying on 'scientists' for information in relation to environmental hazards, as well as relation to educational level of respondents in that area. The level of education has been calculated by creating an average score where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification' (n = 73).

Postcode	Education	Rely on scientists
M	4.4	30.7
SK	3.5	18.2
BL	3.6	14.9
OL	3.2	6.9
WN	3.7	5.6
WA	4.6	6.7
p-value (postcode/rely) < 0.001 p-value (postcode/education) < 0.001		

Initially, statistically significant differences also appeared in relation to age and trust in scientists (p-value < 0.001). As the variables educational level and age were related (p-value < 0.001), this relationship was explored, and it was found that the age groups which had received more formal academic education relied on scientists the most, reiterating the relation between education level and trust in scientists (Table 4.7).

Table 4.7 Percentage of respondents by age reporting to trust 'scientists' for information in relation to environmental hazards 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely'), as well as relation to educational level of respondents in that age gap. The level of education has been calculated by creating an average score, where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification' (n = 285).

Age	Education	Trust scientists fairly or completely
<24	3.3	76.6
24-49	4.7	89.2
50-80	3.6	64.7
>80	3.6	80.0
p-value (age/trust) < 0.001 p-value (age/education) < 0.001		

Statistically significant differences were also found in relation to educational level and trust in the government (p-value < 0.001) and in environmental organizations (p-value < 0.05). Respondents who had received the most formal education reported higher levels of trust in both these sources. As can be seen in Table 4.8, 48.4% of respondents holding postgraduate qualifications reported trusting 'the government', in contrast to 36.4% of respondents with no qualifications, and 20.8% of respondents holding a university degree reported trusting 'environmental organizations', whereas only 3.8% of respondents with no qualifications did so.

Table 4.8 Percentage of respondents by educational level reporting to trust 'the government' (n= 129) and 'environmental organizations' (n = 288) for information in relation to environmental hazards 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely').

Education	Trust the Government fairly or completely	Trust environmental organizations fairly or completely
No formal qualifications	36.4	3.8
GCSE/ O-Level	32.8	11.2
A-Level/ Higher/ BTEC	27.7	13.2
Vocational/ NVQ	7.4	5.8
Degree or equivalent	31.9	20.8
Postgraduate qualification	48.4	15.9
p-value (education/government) < 0.001 p-value (education/environmental organizations) < 0.05		

Statistically significant differences also appeared for age and respondents trust in the government (p-value < 0.005) and local organizations (p-value < 0.01). As can be seen in Table 4.9, 37.2% of respondents aged under 24 reported trusting 'the government', while only 29.3% of respondents aged 50-80 did. Similarly, 59.6% of respondents aged under 24 reported trusting 'local organizations' while only 44% aged 50-80 did. As the variables age and educational level were related (p-value < 0.001), this relationship was explored further to ascertain whether differences in age corresponded with differences in level of education. It can be seen in Table 4.9, that although the age group that had received the most formal education (24-59) trusted 'the government' and 'local organizations' to a larger extent (33.3% and 50% respectively), it was the younger age group (<24) that perhaps unsurprisingly had fewer formal academic qualifications that trusted both these groups the most (37.2% and 59.6% respectively). However, although educational level might have influenced trust in these sources to a certain extent, differences in relation to age appear to have emerged independently.

Table 4.9 Percentage of respondents by age reporting to trust 'the government' (n = 129) and 'local organizations' (n = 185) for information in relation to environmental hazards 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely'), as well as in relation to the educational level of respondents in that age gap. The level of education has been calculated by creating an average score, where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification'.

Age	Education	Trust Government fairly or completely	Trust local organizations fairly or completely
<24	3.3	37.2	59.6
24-49	4.7	33.3	50.0
50-80	3.6	29.3	44.0
>80	3.6	20.0	40.0
p-value (age/government) < 0.005 p-value (age/local organizations) < 0.01 p-value (age/education) < 0.001			

Initially, statistically significant differences also emerged in relation to age and trust in environmental organizations (p-value < 0.005), as well as in relation to postcode area and trust in the government (p-value < 0.05). These, however, corresponded with patterns of educational level, as this was related to both age (p-value < 0.001) (Table 4.10) and postcode area (p-value < 0.001) (Table 4.11). It was the age groups and postcode areas where respondents were more educated that the government and environmental organizations were trusted to a greater extent.

Table 4.10 Percentage of respondents by age reporting trust of 'environmental organizations' for information in relation to environmental hazards 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely'), as well as in relation to the educational level of respondents in that age gap. The level of education has been calculated by creating an average score, where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification' (n = 129).

Age	Education	Trust environmental organizations fairly or completely
<24	3.3	76.6
24-49	4.7	85.8
50-80	3.6	74.1
>80	3.6	20.0
p-value (age/environmental organizations) < 0.005 p-value (age/education) < 0.001		

Table 4.11 Percentage of respondents by postcode area reporting trust in 'the government' for information in relation to environmental hazards 'fairly' or 'completely' in the categorical 5-point Likert-type scale ('not at all', 'not very much', 'I don't know', 'fairly', and 'completely'), as well as in relation to the educational level of respondents in that age gap. The level of education has been calculated by creating an average score, where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification' (n = 129).

Postcode	Education	Trust the Government fairly or completely
M	4.4	34.7
SK	3.5	33.8
BL	3.6	10.6
OL	3.2	32.8
WN	3.7	44.4
WA	4.6	60.0
p-value (postcode/government) < 0.05 p-value (postcode/education) < 0.001		

Statistically significant differences were also found in relation to preferred media. Women were more likely to rely on 'special events (e.g. science festivals, exhibitions, etc.)' (p-value < 0.05) as the medium to acquire information about environmental hazards: 6.3% of women reported using this medium and only 1.9% of men did (Table 4.12).

Table 4.12 Percentage of respondents by gender reporting using 'special events' (n = 32) for information in relation to environmental hazards.

Gender	Specialist events
F	6.3
M	1.0
p-value < 0.05	

Differences also emerged in relation to age and social media (p-value < 0.001), and age and newspapers (p-value = 0.01). Older respondents preferred getting information about the environment from newspapers while younger respondents favoured social media. As can be seen in Table 4.12, 77.7% of participants under 24 years old reported using 'social media', while only 45.7% of respondent aged 50-80 did, and no participant over 80 years old reported using this medium. In the case of 'newspapers' (Table 4.13), 80% of respondents over 80 reported using them to get information about the environment, while only 43.6% of respondents

aged under 24 did. Although age and educational level were related (p-value < 0.001), as can be seen in Table 4.13 the relationship between media and age was independent of educational level.

Table 4.13 Percentage of respondents by age reporting using 'social media' (n = 239) and 'newspapers' (n = 201) for information in relation to environmental hazards, as well as in relation to the educational level of respondents in that age group. The level of education has been calculated by creating an average score, where 1 is 'no formal qualifications' and 6 is 'postgraduate qualification'.

Age	Education	Social media	Newspapers
<24	3.3	49.7	72.7
24-49	4.7	42.4	68.4
50-80	3.6	81.4	66.4
>80	3.6	2.5	80.0
p-value (age/social media) < 0.001 p-value (age/newspapers) < 0.01 p-value (age/education) < 0.001			

Furthermore, the more formal academic education respondents had received, the more they reported using specialist publications (p-value < 0.001). As can be seen in Table 4.13, 6.3% of respondents holding postgraduate qualifications and 5.2% of respondents with university degrees reported relying on 'specialist publications', while only 0.5% of respondents with no formal qualifications reported using these. This pattern was also observed in the case of 'official websites' (p-value < 0.001) (Table 4.14), where 48.4% of people holding postgraduate degrees reported relying on them and only 9.1% with no formal qualifications did.

Table 4.14 Percentage of respondents by level of education reporting to use 'specialist publications' (n = 62) and 'official websites' (n = 124) for information in relation to environmental hazards.

Education	Specialist publications	Official websites
No formal qualifications	0.55	9.1
GCSE/ O-Level	0.27	18.0
A-Level/ Higher/ BTEC	3.01	41.5
Vocational/ NVQ	0.82	33.3
Degree or equivalent	5.21	36.2
Postgraduate qualification	6.30	48.4
p-value (education/specialist publications) < 0.001 p-value (education/official websites) < 0.001		

Table 4.15 provides an overview of the analysis conducted in relation to independent variables. The green cell shows which independent variables affected each dependent variable. For example, there are statistically significant differences in how people with different educational level and in different postcode areas perceive pollution. These two independent variables (i.e. educational level and postcode area), however, are related (p-value < 0.05), which means that the effect of one could actually correspond with the effect of the other. This indicated that these two variables should be analysed in combination, to see if differences in postcode area correspond with differences in educational level, that is, to see if the postcode areas where participants had received more formal academic education perceive pollution to be worse. After this analysis, the conclusion reached was that the effect of postcode area was independent of educational level (this can be seen in Figure 4.2). The yellow cells, on the other hand, show that although the relation between these variables were *a priori* statistically significant (p-value < 0.05) (e.g. age and trust in scientists), the relation was not real and it was instead a product of another independent variable (i.e. educational level in the case of trust in scientists). This table also shows the relationship between independent variables (based on the p-values).

Table 4.15 Relationship between independent and dependent variables that are statistically significant (x), relationships that appear to be independent from the effect of other independent variables (green) or that appear to be the effect of another independent variable (yellow). Blank cells show no statistical significance in the relationship between variables. The relationship between independent variables (based on p-values) is also presented (n = 365).

Dependent Variables		Independent Variables: Education	Postcode	Age	Income	Gender
Threat	Pollution	x	x			x
	General	x	x			
Source	Scientists	x	x			
Trust	Scientists	x		x		
	The government	x	x	x		
	Environmental organizations	x	x	x		
	Local organizations	x		x		
Media	Special events					x
	Social media			x		
	Newspapers			x		
	Specialist publications	x				
	Official websites	x				

Relationship between independet variables		
Education	Postcode	p-value < 0.001
Education	Age	p-value < 0.001
Education	Gender	p-value > 0.05
Gender	Postcode	p-value > 0.05

4.4 Discussion

According to the findings, pollution was perceived to be the main threat (57%) over other environmental (e.g. flooding) and non-environmental (e.g. terrorist attacks or unemployment) threats (Figure 4.2 and Figure 4.3). Overall, questionnaire respondents not only reported being affected by pollution, but also agreed that it is 'fairly' threatening (Figure 4.3). As explained in the previous section, most of the questionnaires were conducted at street level and in conversation with all participants, where it became clear that participants thought of pollution as air pollution. Therefore, for the purpose of examining findings in light of relevant literature, the focus of this discussion has been set on air pollution. As is the nature of this research method, participants sometimes completed the questionnaires on their own with no or little interaction about what form of pollution they referred to. Although this doesn't affect the overall conclusions of this chapter or the recommendations for communication suggested in this thesis (Chapter VI), in the future, different forms of pollution would be better presented as different options (e.g. water, noise, or plastic) to provide a more accurate percentage of the extent to which citizens are aware of air pollution specifically.

Results in this study differ from those in a similar study in California by Cisneros et al. (2017), where they found air pollution to be the fourth highest concern after unemployment, crime, and obesity. This stresses first, that different contexts (i.e. cities or conurbations) bring about different environmental perceptions as well as relative priorities, and second, that a careful exploration of local environments is necessary.

The fact that only 57% of questionnaire respondents felt affected by pollution seems low considering the air pollution situation in GM where many locations, especially around urban centres, have recorded annual mean concentrations of nitrogen dioxide (NO_2) above or close to the annual limit set by the EU (40 µg/m^3), in some cases reaching 65 µg/m^3 (GMCA, 2016a) (Chapter II, Table 2.1). The explanation for this could be found in studies such as Xu et al. (2017), which find

how the impacts associated with air pollution tend to be perceived by citizens as detrimental at a societal level and not specifically to oneself. The fact that participants were asked to respond in their own individual experience and not at a societal level might influence this result. This also relates to the fact that although participants perceive pollution as the main environmental concern, they failed to fully grasp its negative health consequences (23.3%), with damage to buildings (59.7%), or to the local environment (39.7%) perceived to a greater extent (Figure 4.4). An explanation for this can be found in different studies showing how health impacts of air pollution are often seen as an impersonal risk, and that the people who are more likely to notice air pollution and its resulting health impacts are those with pre-existing health conditions, who spend more time outdoors, who have an active outdoor life (e.g. runners), or who commute by foot or bike (Bickerstaff and Walker, 2001; Van den Elshout, 2007; Saksena, 2011; Xu et al., 2017).

In investigating relative priorities, the questionnaire findings show that terrorist attacks were perceived to be the second biggest threat after pollution (Figure 4.3). This implies that time can be an important factor that could guide further research, as on 22nd May 2017, during the very early stages of questionnaire data collection (undertaken between 21/03/2017 and 15/03/2018), Manchester suffered a terrorist attack where 23 people were killed and more than 100 were injured (Dodd et al., 2017).

Pollution was perceived to be a bigger threat by people who had received the most formal education (Table 4.1). This is in line with most studies finding that people with higher levels of formal education are more aware of air pollution and its health impacts (Badland and Duncan, 2009; Kim et al., 2012; Li and Tilt, 2019), look for more air pollution related information (Yang and Huang, 2018), and are more accepting of mitigation measures (Sun et al., 2016). Conversely, some studies focusing on China find contradictory results, such as the finding that it is people with a lower educational level who appear to be more worried about air pollution (Lai and Tao, 2003; Chen et al., 2017). One possible explanation is that perceptions of risk are linked to media consumption, and that the sources employed by those with a lower educational level might portray this issue in more alarming ways than

other more expert sources on which people with higher levels of formal education rely. An explanation for this contradiction, then, could be due to differences in the nature of the media coverage in these two very different socio, urban and geo-political locations (i.e. China and the UK).

The questionnaire revealed that pollution was also perceived to be worse by people living in larger and more populated postcode areas (Table 4.2). Other studies reach similar conclusion when they find that citizens rely on sight and smell to make inferences about air pollution (Bickerstaff and Walker, 2001). Studies show how people living in urban centres and in more populated areas, where there is a larger concentration of vehicles, buildings, and people, are more likely to report air pollution as a threat (Bickerstaff and Walker, 2001; Howel et al., 2003; Badland and Duncan, 2009; Saksena, 2011; Pantavou et al., 2017; Ramírez et al., 2017; Xu et al., 2017). In this study, there were no differences in perception linked to age or income, which contradicts other studies that find that older populations and people with lower incomes perceive air pollution and its health impacts to be more threatening (Lai and Tao, 2003; Kim et al., 2012; Becken et al., 2017; Chen et al., 2017).

When it comes to gender, findings show that women perceive threat in general to a greater extent (Table 4.3), and in the largest and most populated postcode area (M) they also perceive pollution to be more threatening if compared to men (Table 4.4). Although some studies find no gender differences (Howel et al., 2003; Kim et al., 2012), in most, women report air pollution and risks related to health to be more threatening compared to men (Flynn et al., 1994; Lai and Tao, 2003; Lepp and Gibson, 2003; Kahan et al., 2007; Cisneros et al., 2017). This also relates to the aforementioned idea that an active lifestyle, spending more time outdoors, or being more exposed to city centre environments (i.e. cars, buildings, people, etc. that are generally associated to air pollution) also increase perception of the air pollution problem. It could be hypothesised that women (especially in postcode area M) are more exposed to air pollution signifiers and are more likely to perceive the threat of air pollution and its health impacts, because – as explained in Chapter II (Section 2.2.3) – women:

(1) have shorter commutes than men and are therefore more likely to commute by foot;
(2) are more reliant on public transport and spend longer periods of time standing next to busy roads; and
(3) in the UK conduct 60% of unpaid work, which includes childcare and spending time outdoors (Root et al., 2000; Polk, 2003, 2004; Marion and Horner, 2007b; Hanson, 2010; Basarić et al., 2016),

In terms of agency and responsibility to act, findings show that respondents report environmental issues, especially pollution, being caused by a combination of human activity and natural forces, but with a predominance of human activity (Figure 4.5). Another study – concerned with emissions in relation to climate change, reaches a similar conclusion, with questionnaire respondents found to believe the causes as being an uneven combination of human activity (47%) and natural forces (37%) (Leiserowitz et al., 2011).

Participants in this study believe international organizations, national and local governments, and individuals to be the most accountable to act in response to pollution and other environmental hazards. Respondents, then, impart more responsibility to themselves than to business, environmental organizations, or scientists (Figure 4.6). Other studies also find that individuals acknowledge their responsibility for personal actions in relation to environmental issues, and understand this as a joint effort to be shared with governments (Bickerstaff, Simmons, & Pidgeon, 2006; Lorenzoni & Pidgeon, 2006; Zwick & Renn, 2002).

When it comes to information sources, the media was identified to be most employed (80% of questionnaire respondents), but this and the government are not highly trusted. On the other hand, scientists and environmental organizations are highly trusted but are only used by 20% and 23% of respondents, respectively (Figure 4.7). Other studies also find that information about emissions, and scientific information more generally, is more credible if supplied by scientific institutions or environmental organizations than if supplied by the government or the media (Brewer and Ley, 2013). This finding also points towards the importance of science communication: scientists are trusted and could therefore be key in

encouraging behavioural change, but they only reach about 20% of the population. In terms of independent variables, findings in this thesis show that the higher formal education respondents had, the more they trust scientists (Table 4.4) and environmental organizations (Table 4.7); and that more formally educated and younger respondents also trust the government and local organizations to a greater extent (Table 4.7 and 4.8). These behaviours can also be found in other studies showing that when it comes to scientific and technological information, the more formal education respondents had, the more likely they are to trust scientists, and that younger generations are more likely to trust governments (Anderson et al., 2012). An initially perplexing finding not reported in other similar studies is the greater reliance on scientists for information by respondents living in larger postcode areas. As explained, however, in the findings section (Table 4.5), this could simply be a 'hidden variable effect' not really a product of the postcode area but of the high educational level of respondents in M. On the other hand, the fact that this reliance on scientists does not take place in postcode area WA, where respondents are most educated, could also indicate that the environment typified by postcode area has its own independent effect. Such an effect could arise from several contributing factors. One possible explanation could be that people living in postcode area M are in contact with scientists to a greater extent through the multiple special events and science activities that take place there. For example, most of the events hosted as part of the Manchester Science Festival, where scientists and members of the public meet face-to-face, tend to happen around postcode area M. Similarly, there are three universities based in this postcode area (Manchester Metropolitan University, The University of Manchester, and University of Salford) which often hold public events, such as book launches or public lectures.

These findings also show that TV, social media, and newspapers are preferred over other forms of communication associated with more specialised sources (e.g. scientists), such as official websites, specialist publications, and events. This is in line with other studies concluding that, although science websites or blogs are more trusted, they are not as widely used as TV or newspapers (Brewer and Ley, 2013). The finding that younger generations prefer social media while older respondents report relying on newspapers is consistent with other studies (Zhao,

2009). It is not surprising that respondents with a higher formal education report employing special publications and official websites, when findings in this thesis as well as in other studies also show that it is the people holding higher formal qualifications who rely on and trust information provided by scientists the most (Brewer and Ley, 2013). An interesting observation that has not emerged in other similar studies, and that would merit further exploration, is the fact that women report relying on special events to a greater extent than men.

These findings highlight that the preferred sources for seeking information about environmental issues are mainly one-way communication formats, such as TV, newspapers, or social media (even if this last one can also be employed in a two-way process). Other formats that work for two-way communication explored in Chapter III, such as games, are still not a widely used media.

When it comes to independent variables, this chapter shows that educational level is key in shaping perception in relation to pollution, trust, and information consumption habits. Age and socio-environmental factors embodied within postcode districts also appear to exert influence to a lesser extent with their influence intertwined with that of educational level. Gender is an interesting demographic variable, as it has been found to shape the perception of threat and pollution. Its influence is independent of educational level and postcode area and it is the most complex and yet least explored factor in the literature. A slowly growing body of work concurs on the importance of gender when it comes to the perception and response to emissions, sustainable mobility, and energy consumption (Denton, 2002; Marion and Horner, 2007a; Polk, 2009; Hanson, 2010; Chalifour, 2011; Levy, 2013; Madariaga, 2016b). These studies agree that further research that focuses on women is imperative because their mobility, access to the city, and experiences of air pollution are all shaped by gender differences in unpaid work, economic inequality, longer life expectancy, and fear of crime (Root et al., 2000; Garcia-Ramon et al., 2004; Johnsson-Latham, 2007; Polk, 2009; Chalifour, 2011; Buckingham, 2016, 2018; Madariaga, 2016b; Beebeejaun, 2017; Pearse, 2017).

When it comes to the limitations of this study, it has to be acknowledged that due to an overrepresentation of respondents with university degrees and postgraduate qualifications, this study might produce overly optimistic results in relation to how aware GM residents are to environmental pollution. A weighted analysis of the questionnaire data was considered in order to correct for this overrepresentation but was discarded for two reasons. Firstly, it is not the aim of this thesis to establish an exact percentage of how environmentally aware people are, but rather to draw recommendations for communication and engagement. This study is concerned with identifying whether there is a general awareness but a lack of action in adopting positive behaviour (such as active forms of transport), or whether there is a general lack of awareness in GM. Secondly, the remainder of this thesis is concerned with an in-depth exploration of the role of gender and differences in educational level are not be found across genders, meaning that differences in perception between male and females still hold regardless of this overrepresentation.

Finally, whilst this study explores a specific locality (a conurbation in England) offering results that are context-dependent, the methods (i.e. questionnaire study) and the approach (i.e. exploring perception and relative priorities in a local setting) that it employs can be transferred to, and replicated in, other geographical context worldwide. This would give raise to studies, such as the one in California (Cisneros et al., 2017), that explore a series of interrelated factors affecting human perception.

4.5 Summary

This chapter shows that approximately 57% of respondents are aware of pollution in GM, but that they fail to fully grasp its health consequences. Communication appears to be taking place through one-way communication processes – rather than through the more effective dialogical approaches that were discussed in Chapter III, and mainly through the media – even if this is not highly trusted when compared to scientists. This chapter provides evidence that there are differences

in perception and information consumption habits at a city or conurbation level that arise from factors such as educational level, postcode area, age, or gender. It supports the need for more social studies dealing with public perception and for a careful exploration of social and contextual dimensions that give rise to differences in perception, and behaviours, as well as communication needs.

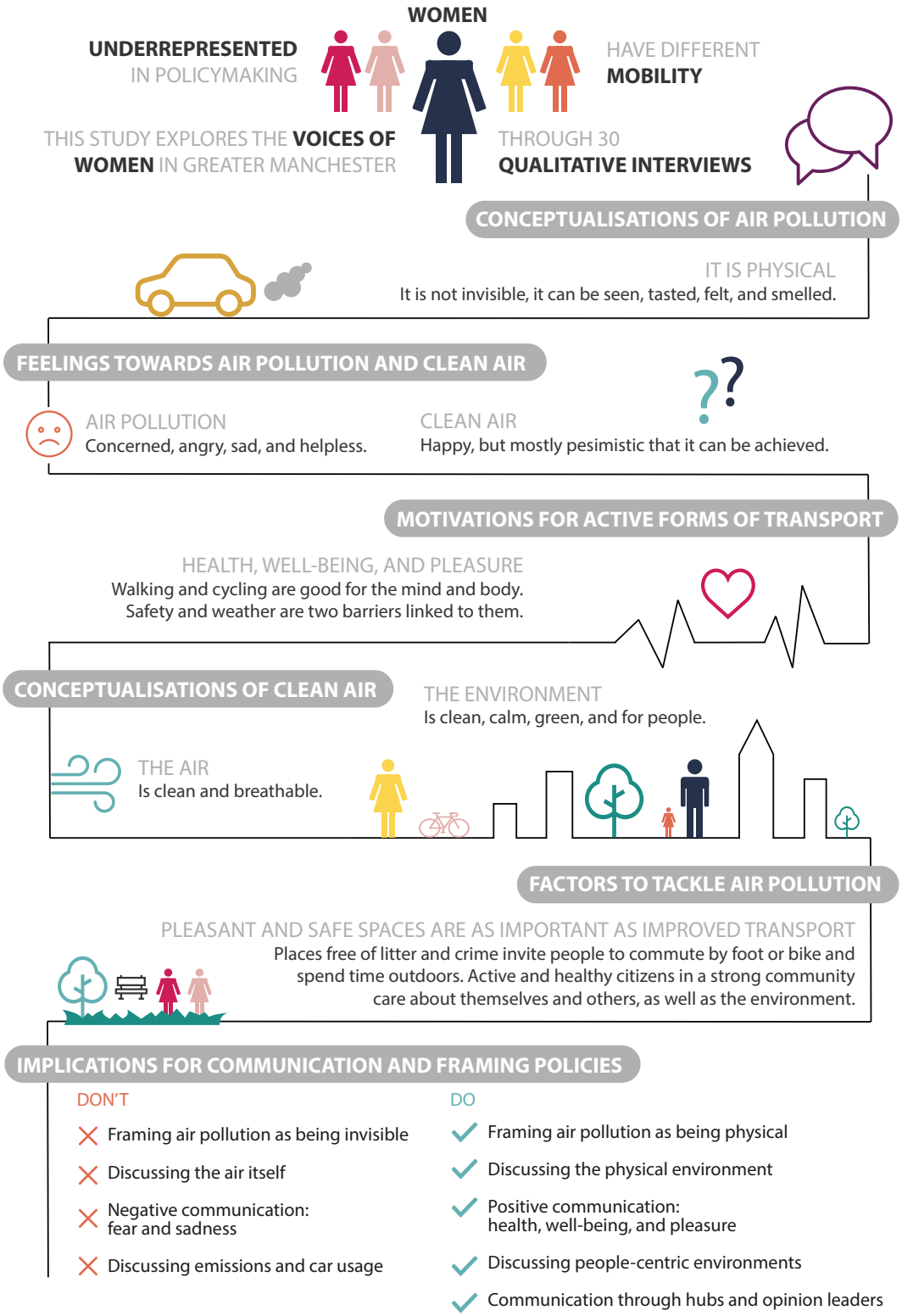
Importantly, this chapter also demonstrates that gender is key in shaping perception of air pollution. It subscribes to the idea that although it has been established that unpaid work, economic inequality, longer life expectancy, and fear of crime shape women's mobility (Root et al., 2000; Garcia-Ramon et al., 2004; Johnsson-Latham, 2007; Polk, 2009; Chalifour, 2011; Buckingham, 2016; Madariaga, 2016b; Beebeejaun, 2017; Pearse, 2017), the needs and experiences of women have been underexplored and are still poorly understood. This chapter concurs with studies such as Hanson (2010) or Polk (2009), who argue that a gender perspective is central to sustainable mobility, and consequently to air pollution, and that further qualitative research in this area is imperative.

Chapter V

Exploring the voices of women in relation to air pollution and clean air

Infographic

The voices of women



Overview

This chapter presents data from 30 qualitative interviews with women in Greater Manchester (GM). It explores how women experience air pollution and imagine an urban environment with clean air. Findings presented in this chapter are a series of themes that emerged from performing a content analysis of the interview transcripts through a coding exercise. Transport is at the epicentre of these interviews as participants perceive it as the main source of air pollution as well as their major individual contribution. Women in this study have physical experiences of air pollution: it can be seen, felt, smelled and tasted. Similarly, health and well-being are at the heart of their discourses and appear to be strong motivators for active forms of transport, with participants understanding that social sustainability is essential for environmental sustainability. They believe that factors such as crime or homelessness influence the experience of the outdoors and mobility, and are consequently indirectly related to air pollution. These findings are about understanding perception and uncovering the mental frames that are activated when thinking about air pollution and clean air, and through which new information and policies can be processed and evaluated. This chapter is about gaining insights into how to communicate the challenge of air pollution, as well as how to design and frame structural changes for clean air. These insights originate from the experiences of women but are relevant for society at large.

The interview transcriptions that were used in this chapter can be found in the following data repository:
Loroño-Leturiondo, M.; Illingworth, S.; O'Hare, P.; Hoon, S.R.; Cook, S. (2019): Qualitative Interviews with Women in Greater Manchester (UK) about their conceptualizations of air pollution and a city with clean air. Centre for Environmental Data Analysis, *10 September 2019*. doi:10.5285/891dc49a623c4d4a82c2ee17cd85d773. http://dx.doi.org/10.5285/891dc49a623c4d4a82c2ee17cd85d773

5.1 Introduction

A transition towards clean air requires rapid policy and lifestyle changes. It requires suitable infrastructure in place as well as a shift in personal travel choices. Both of these important areas of action require effective public engagement (Clarke et al., 2018; Perlaviciute et al., 2018). The public, however, embraces a large and heterogeneous group of people and communities that cannot be effectively engaged following a one-size-fit-all strategy. In multicultural and socially diverse cities and conurbations (including GM), differences in environmental perception, contribution, and vulnerability coexist (Bradley, 2009; Kaijser and Kronsell, 2014). In other words, global environmental challenges, such as air pollution, require a more holistic understanding of human perception and behaviours, but also a careful exploration of different societal groups.

This chapter is concerned with one societal group in particular: women. As explained in Chapter II, women have different mobility patterns to those of men (Root et al., 2000; Garcia-Ramon et al., 2004; Bauer, 2009; Madariaga, 2016b; Roberts, 2016a; Beebeejaun, 2017; Alber, 2018; Buckingham, 2018). A greater responsibility for unpaid work, economic inequality, longer life expectancy and related biological characteristics, as well as a stronger feeling of insecurity, shape how women travel. Consequently, as seen in Chapter IV, their experiences of air pollution are also different to those of men.

Despite the differences in mobility patterns, the voices and experiences of women have traditionally been underexplored and underserved. Transportation and energy sectors, as well as the climate change and air pollution debates, have been male-dominated (Garcia-Ramon et al., 2004; Bradley, 2009; MacGregor, 2009; Polk, 2009; Kaijser and Kronsell, 2014; Pearse, 2017; Hemachandra et al., 2018). The outcomes have been a series of structural changes prioritizing forms of transport for the norm-bearer and giving preference to, for example, paid rather than unpaid employment (Madariaga, 2016b).

Although the voices of women have been underexplored, a growing body of interdisciplinary research agrees that gender is central in dealing with carbon dioxide (CO_2) emissions and climate change (e.g. Christensen, Brengaard, & Oldrup, 2009; Denton, 2002; Hemmati & Röhr, 2009; Johnsson-Latham, 2007; Kaijser & Kronsell, 2014; MacGregor, 2009; Pearse, 2017; Polk, 2009), sustainable mobility (e.g. Marion and Horner, 2007a; Polk, 2009; Hanson, 2010; Levy, 2013; Buckingham, 2016, 2018; Madariaga, 2016b), and energy consumption (e.g. Chalifour, 2011; Denton, 2002). Through a series of qualitative interviews, this chapter explores how women experience air pollution and how they envision the transformation to clean air in GM. This chapter advances knowledge in relation to public perception of air pollution with a specific focus on women, in relation to the mental structures employed to think about air pollution and clean air, and consequently, in relation to public engagement with air pollution. This chapter also sets a series of recommendations for a more effective framing of polices and communication; recommendations that can guide policymakers in local authorities – such as the Association of Greater Manchester Authorities (AGMA), Greater Manchester Combined Authorities (GMCA), and Transport for Greater Manchester (TfGM); as well as charity organizations – such as Friends of the Earth and Greenpeace.

This chapter is concerned with **research question three (RQ3)** presented in Chapter I: how do women in Greater Manchester conceptualize air pollution and envision a city with clean air?

5.2 Qualitative interviews with women

This section is concerned with the methodological aspects of exploring the voices of women through qualitative interviews. It presents the methodological stance as well as considerations related to the chosen methods for data collection and analysis.

5.2.1 Methodological stance: constructionism and interpretivism

This part of the thesis, which explores the voices of women, follows a qualitative research strategy. As explained in Chapter IV, there is a mixed-method sequence adopted across the thesis as a whole in which the qualitative interviews are the principal method (Morgan, 1998), following on from the quantitative questionnaire (Chapter IV) in which gender was found to be a significant variable influencing public perception.

Questions of ontology and epistemology or, in other words, questions in relation to the nature of reality, and how a researcher can access that reality, are central to the research process as these will guide the way data are collected, analysed, and reported (Guba and Lincoln, 1994; Bryman, 2012), (see also Section 4.2.1). In considering the nature of reality, this work takes a social constructionist approach according to the four assumptions outlined by Burr (2003:4–5): that observations of the world do not always reveal its nature, that the way the world is understood is subject to where one lives, that knowledge is constructed between people and in relation to one another, and that differences in understanding the world also bring about different actions.

The social constructionist approach, however, has been criticised when applied to the nature of environmental challenges (Burningham and Cooper, 1999; Jones, 2002). This criticism arises from the premise that there is an objective truth and independent reality of nature, and that stating that reality is constructed could lead to the belief that environmental challenges, such as air pollution, are not real (Ibid.). What is criticised here, however, is not social constructionism as such, but an extreme view of this approach – that is, social constructionism manifested in the 'extreme' (or strict) version rather than the 'mild' (or contextual) one (Burningham and Cooper, 1999; Jones, 2002). Most studies subscribe to a mild version of social constructionism, acknowledging an independent reality of nature and environmental issues alongside a social reality that is constructed (Ibid.).

In line with the most widely applied version of social constructionism, this work too adopts a mild perspective. It subscribes to the idea that air pollution exists regardless of how people construct it; but also to the belief that air pollution is a social phenomenon where citizens are sources and victims, and have to adapt to and mitigate against it. Returning to Burr's (2003) assumptions, knowledge and social action go hand-in-hand and differences in understandings will bring about different actions (or inaction) in the face of air pollution. If knowledge is subject to where one lives (Burr, 2003), as well as to social, economic, political, or gender factors (Guba and Lincoln, 1994), then social constructionism in this regard is also concerned with the question of whose views are to be heard and acted upon, and in turn, with the aim outlined in this chapter of exploring how women, in particular, construct the very real challenge of air pollution.

In relation to how the researcher can access these constructions, this research relies on interpretivism (Guba and Lincoln, 1994; Bryman, 2012). This position argues that the study of the social world is different from that of the natural world (Ibid.). According to interpretivism, reality has a meaning for human beings and they act on the basis of the meaning that they attribute to reality. In turn, the researcher provides an interpretation of that interpretation. As Bryman (2012:31) explains it: "there is a double interpretation going on". The aim of qualitative research according to interpretivism is to tell a story from the data acknowledging the active role of the researcher in analysing and describing the data:

> "this is not to say that when social researchers write accounts of their studies they deceive us, but rather that the accounts of the findings and how they were arrived at tend to follow an implicit template that emphasizes some aspects of the research process but not others" (Bryman 2012:15).

This qualitative part of the research is concerned with words and a focus on meaning and identifying themes (Bryman, 2012; Silverman, 2013). The focus is set on generating hypotheses rather than testing these and thus following an inductive approach to theory (Ibid.). Generating theory in this regard involves an iterative process between data collection and analysis, where codes are generated

from the data and combined to build greater structures, such as concepts or a combination of these theories (Bryman, 2012). In this sense:

> "A researcher does not begin a project with a preconceived theory in mind. Rather, the researcher begins with an area of study and allows the theory to emerge from the data. Theory derived from data is more likely to resemble the 'reality' than is theory derived by putting together a series of concepts based on experience or solely on speculation (how one thinks things ought to work)" (Strauss and Corbin, 1998:12).

There are different kind of theories that can be generated from qualitative research. One important distinction is between substantive and formal theory (Glaser and Strauss, 2009). If substantive theory explains a particular social context, formal theory is more general (Ibid.). In this particular study, the theory that is generated is substantive as it derives from the exploration of one particular context, i.e. women in GM.

5.2.2 Data collection method: qualitative interviews

Interviews are the most common data collection method in qualitative research as they offer a rich source of data (Silverman, 2011, 2013; Bryman, 2012; King et al., 2018). It is a research technique that resembles daily conversations and, if conducted correctly, feels natural to both the researcher and the interviewee (King et al., 2018).

The type of interview selected for this study was the semi-structured interview, where interviews were conducted following an interview guide, that is, a predesigned list of questions (Table 5.1) (Bryman, 2012; Clifford et al., 2016). This interview guide was flexible and used to orient discussion, but participants were allowed, and encouraged, to take the interview in the direction they wished. This led to follow-up questions being asked to find out more about specific mentions and answers. Although follow-up questions varied across interviews the same

wording was employed to ask the questions from the interview guide, thus assuring consistency (Bryman, 2012).

The interview was structured in three sections. The first section worked as an ice-breaker and allowed the gathering of data about the background of the participants (Table 5.1) and to calculate the carbon footprint of the participants using an online and publicly available tool (footprint.wwf.org.uk) designed by the World Wide Fund for Nature (WWF). This initial section was useful in getting participants to open up and to start an initial informal discussion about behaviours in different sectors and emissions. These series of questions about the background of the participants allowed were employed for the sample description and to verify that the sample was diverse. The second and third sections were where the qualitative data collection took place. The second section focused on the presence of air pollution and participants were asked to describe their feelings, understandings, and motivations for transport behaviour (Table 5.1). The third part of the interview asked participants to think about the future and to imagine a city with clean air, to describe their feelings and understandings, and to consider the solutions they would implement to achieve that (Table 5.1).

Table 5.1 Interview guide employed in the qualitative interviews.

Profile Questions	Time
Pseudonym: Age: Postcode: Occupation: Number of household members and relation: Number of children: Who is mostly in charge of household chores? E.g. shopping. Who is mostly in charge of escorting children and family members to school, doctor, etc.? Which would you say are your main forms of transport? What is your carbon footprint?	10’

Present: Air Pollution	Time
Emotions/Feelings: How do you feel when you hear 'air pollution'? Description: How would you describe air pollution? I am not looking for a technical definition. I want to know your personal experience. Contributors: Which would you say are the biggest contributors to air pollution? If you think of your daily tasks, or actions which would you say you are contributing to air pollution? Motivations for transport: When you decide on a form of transport, what do you value most? Think retrospectively to when you have used different forms of transport.	25’
Future: A city with clean air	Time
Emotions/Feelings: How do you feel when you hear 'a city with clean air'? Description: How would you describe a city with clean air? The future city: If you could change anything in Greater Manchester, so that it becomes a city with clean air, what would you change? This could be anything at all and time and money are not a constraint.	25’

The motivation to include questions about emotions and feelings was found in different studies explaining how these are key in risk perception (e.g. Slovic, 2010). Different studies concur that although fear and negative emotions have been effective in motivating people to seek environmental information, they have also paralysed them in taking action; and how emotions of hope have been shown to be more effective in motivating behavioural change (O’Neill and Nicholson-Cole, 2009; Moser and Dilling, 2011; Myers et al., 2012; Roeser, 2012). The aim of these questions was to explore what emotions women link to air pollution and clean air, and whether these emotions are encouraging or if they are preventing women to act. Questions asking to describe air pollution and a city with clean air were included to ascertain whether women also conceptualized it as something ungraspable and invisible (Defra, 2017; EEA, 2017; WHO, 2018), and to explore if the role of signifiers of air pollution and clean air (e.g. vehicles, buildings,

greenspace) were key in their conceptualizations (Bickerstaff and Walker, 2001, 2003; Howel et al., 2003; Bickerstaff, 2004; Saksena, 2011; Johnson, 2012; Smallbone, 2012; Xu et al., 2017). The question in relation to general and individual contributors to air pollution was designed to gather data in relation to what sectors women believed to contribute most, but also to explore notions of responsibility. This question was included as different studies show how awareness and perceived responsibility for emissions can be translated into whether the necessary positive behaviours are adopted (Bickerstaff and Walker, 2002; Whitmarsh, 2005). The question about motivations for different forms of transport was shaped by the pilot study, as it became clear that transport was at the centre of the discourses. This question was also inspired by studies such as Kollmuss and Agyeman (2002) or Gifford and Comeau (2011), and was designed to investigate if the health frame is also present in the discourses of women when referring to active forms of transport, and which other frames they employed to think about other forms of transport. Finally, the question about imagining a future city with clean air was motivated by studies such as Eames and Egmose (2011) and Nieuwenhuijsen and Khreis (2016), which highlight that the views of citizens of a sustainable future must be explored and integrated, as they are central to designing attractive and liveable urban environments.

In order to guarantee that the questions were easy to understand by the participants, that they were generating relevant data, and that the flow and length of interviews was suitable, a pilot study was conducted with five participants. The pilot study was helpful in getting the right framing of the questions, in finding out what type of follow-up questions were needed, and in modifying questions so that they became more relevant. For example, the question about motivations for choosing a particular form of transport (Table 5.1) was included as participants discussed transportation as their main contributor to air pollution. In the pilot study, it became clear that interviews were heavily oriented to transportation over, for example, agriculture.

Interviews were planned to last approximately one hour and took place in different places in GM: sometimes in the participant's homes, but most often in public spaces such as cafes, universities, or participants' workplaces. In order to

safeguard the researcher's own safety in the field, it was arranged to meet in public spaces when possible, or the location and estimated finishing time was shared with colleagues. Before the interviews started, the background of the researcher, the project, and the structure of the interviews were explained to the participants, and verbal and informed consent was ascertained to proceed with the interview, to record it, and to use the data in the form of this thesis, or in subsequent publications or conference presentations. In order to anonymise the data, participants were asked to choose a pseudonym and this was used when saving data and reporting findings. With the approval of Manchester Metropolitan University's Academic Ethics Committee, the anonymised data was stored on a secure University server, and was password protected during the data collection and analysis processes, before being made publicly available through the Centre for Environmental Data Analysis (CEDA) data repository (Loroño-Leturiondo et al., 2019a). Although there was no form of compensation for participating in the study, participants were asked about their motivations to participate, and agreement was made to feed the results of the study back in the form of an academic paper or report so that they could comprehend the overall level of their contribution. The interview guide as well as the informed consent document received full ethical approval from Manchester Metropolitan University's Academic Ethics Committee (Reference Number: 0660). The informed consent document that was read to the participants can be found in Appendix 5.1.

The researcher's positionality, that is, how the researcher presents themselves, influences how participants react to the study and respond to the questions asked (Savin-Baden, 2010; Corlett and Mavin, 2018). Factors such as class, gender, or race can influence the findings in a study, i.e. power imbalances can influence access to participants or the quality of the data collected. In this regard, the fact that it was a female researcher investigating the experiences and views of women facilitated dialogue, enabling the participants to open up in a safe and secure environment. In other words, in this study the researcher "belonged" to the group of study (Savin-Baden, 2010).

5.2.3 Sampling: purposive and snowball sampling

In this study, participants were invited for interviews following a purposive sampling strategy. Such a sampling strategy assures that the people being interviewed are relevant to the research questions and that different segments of the population are interviewed (Bryman, 2012). In this regard, participants were invited for interviews based on their backgrounds, assuring there was diversity in terms of age, ethnicity, nationality, occupation, co-habitation, responsibility for unpaid work, and number of children. These participants were drawn from personal networks, as well as more widely through a social media post disseminated through Twitter. This sampling strategy was complemented with a snowball sampling technique to expand the sample size of relevant interviewees. This technique involves an initial study poll of subjects selected by the researcher, who in turn invite other members in their networks of similar characteristics (Ibid.). The description of the sample can be found in Figure 5.1.

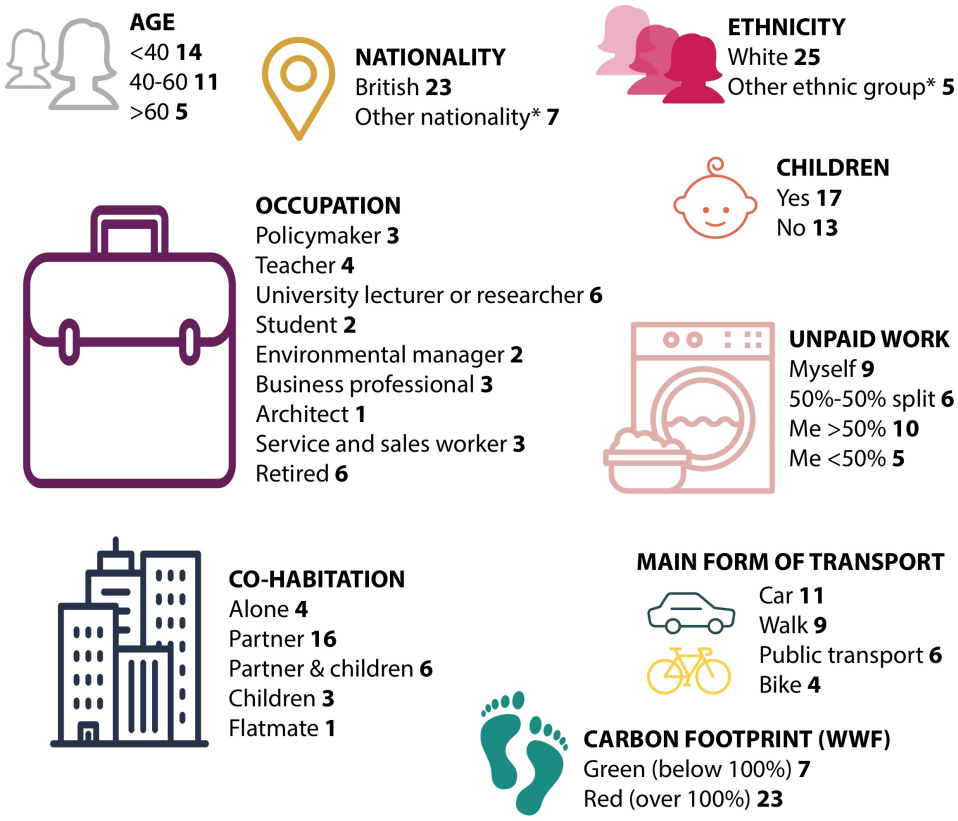


Figure 5.1 A sample description for the qualitative interviews in terms of age, nationality, ethnicity, occupation, responsibility for unpaid work, co-habitation, number of children, main form of transport, and carbon footprint (according to the calculator by WWF). *Other ethnic categories and nationalities were grouped together due to the small number of participants in each.

The sample size in qualitative interviews (as opposed to questionnaires) is not about a specific number that is representative of the population it aims to study, guaranteeing a given level of confidence in the results (Bryman, 2012; King et al., 2018), instead the appropriate sample size is reached when theoretical saturation is achieved (Bryman, 2012). Theoretical saturation is the state when new interviews or data do not generate new codes, themes, or concepts, that is, when new data does not provide new insights. Qualitative interviews involve an ongoing data analysis process that allows the researcher to ascertain when theoretical saturation has been achieved and when the sample size can be considered to be adequate. In this study, theoretical saturation was achieved after 25 interviews, but to assure that voice was given to women of all the different backgrounds and that no new insights were being produced a total of 30 interviews was conducted. Therefore, the final data corpus consists of approximately 30 hours of interviews that were recorded and manually transcribed by the researcher in full.

A problem often related to qualitative research and to its sample size is that of generalization (Miles and Huberman, 1994; Ritchie and Lewis, 2003; Bryman, 2012; Silverman, 2016). As can be seen in this study, qualitative research is about depth rather than breadth, and generally involves a small number of participants. Often the criticism of qualitative studies is the question of whether the findings of such small samples can be generalized to the group it aims to study or to groups in other settings or contexts (Ritchie and Lewis, 2003; Silverman, 2016). The response to this is that, although it is true that findings cannot be generalised, this is not the purpose of qualitative research. The purpose of qualitative research is to generalize to theory and not to populations: “it is the quality of the theoretical inferences that are made out of qualitative data that is crucial to the assessment of generalization” (Bryman, 2012:406). In the particular case of this study, generalization would not be about whether 30 women are representative of all the women in GM or of other women in a similar geographical context, but about the inferences made about the mental frames employed to process air pollution and through which communication can be evaluated and acted upon (e.g. about the physicality of air pollution explained in Section 5.3.1).

5.2.4 Data analysis: content analysis and coding

Social research and qualitative data analysis have often been described as "messy" (Bryman, 2012:15) and filled with "complexity" (Coffey and Atkinson, 1996:4). Data analysis is not always straightforward, and researchers should explore their data from a variety of perspectives (Coffey and Atkinson, 1996). Qualitative data has been described as being "sexy" with rich descriptions and explanations (Miles and Huberman, 1994:1), and the data analysis process as "art" that requires intuition (Ibid.). In other words, qualitative data analysis requires a careful consideration of the right approach, capable of encompassing all these nuances:

> "It is easy to get so wrapped up in one's data (often gathered at considerable personal cost of time an effort) that one cannot see the forest for the trees and cannot get analytical purchase on the data collected. Too many people are so much in love with their data that they cannot bear to disturb their pristine beauty by interfering with them in any way. Both attitudes are sterile" (Coffey and Atkinson, 1996:2).

The methodology adopted for the data analysis in this study is content analysis. As explained in Chapter III (Section 3.2.3), content analysis can be defined as a research method that allows the interpretation of data through a process of coding and identifying themes or patterns (Hsieh and Shannon, 2005). Content analysis can be applied to a multitude of data sources including interviews. Although this study employs qualitative content analysis, providing an in-depth analysis of language and words and how these are being employed by participants, it also looks for the frequency with which each code appears, so that an estimation of the popularity and significance of each code can be established (Ibid.). As in Chapter III, an inductive approach to content analysis was employed in order to avoid preconceived categories. The generation of codes was derived from the data and was guided by RQ3 (i.e. how do women in Greater Manchester conceptualize air pollution and envision a city with clean air?) (Hsieh and Shannon, 2005; Saldana, 2009).

As explained in Chapter III (Section 3.2.3), coding involves assigning a summative and salient word or short phrase to a fragment of data (Saldana, 2009). Coding in this study was performed in two different ways: (1) as a way of indexing data, so that fragments of data that have a common code can be looked at together and to measure the relative incidence of the codes; but also (2) as a way of analysing data, as patterns and relations were looked at, and categories that grouped codes together were formed. Coding is not just labelling but linking. Therefore, researchers go through multiple cycles of coding. The first cycle tends to be descriptive, an initial approximation of the data, labelling what can be found in the data and condensing meaning into manageable units. The remaining cycles (second, third and so forth) allow linking codes and grouping them in categories or concepts that share some characteristics or meanings (Saldana, 2009).

The interview transcripts were coded using the NVIVO software package (Version: 10.2.2) for qualitative data analysis. For the first coding cycle, a combination of 'descriptive coding' and 'emotion coding' (Saldana, 2009) were used, highlighting the meaning of a passage (such as walking infrastructure) and capturing how participants felt (such as angry or sad). As each new code emerged, the interview transcripts were looked at again to explore if they contained any references to the newly developed codes. The first cycle of coding generated 61 codes. In the second coding cycle (and further coding cycles), attention was paid to the codes and to any patterns or relations between them. Through a 'pattern coding' exercise (Saldana, 2009), codes that belonged together were grouped into categories. In this regard, categories can be considered to be groups of codes that share some characteristics (Ibid.).

For example, the following sentence discusses what measures are needed for clean air, it was first coded as WALKING INFRASTRUCTURE, then under ACTIVE FORMS OF TRANSPORT (this category also grouped with other codes such as SAFE CYCLING INFRASTRUCTURE or CYCLING PROFICIENCY), then under TRANSPORT (this category is also grouped with other codes such as CAR or PUBLIC TRANSPORT), and then under DIRECT FACTOR (because transport has a direct impact on air pollution, in opposition to the other category INDIRECT FACTOR).

I guess it would be pedestrianizing the city centre… having kind of areas that would be exclusively for the people who are walking (Cleanairbex)

First cycle code: WALKING INFRASTRUCTURE

Second cycle code: ACTIVE FORMS OF TRANSPORT

Third cycle code: TRANSPORT

Fourth cycle code: DIRECT FACTOR

In order to guide the coding process and make it more transparent a codebook was developed (DeCuir-Gunby et al., 2011). As explained in Chapter III (Section 3.2.3), a codebook is a compilation of codes and definitions that is key to analysing qualitative data as it provides a "formalized operationalization of the codes" (DeCuir-Gunby et al., 2011:138). The codebook generated in this study can be found in Table 5.2, 5.3, 5.4, and 5.5, with each table broken down into different interview questions. Table 5.2 shows the codes generated based on definitions of air pollution and clean air. Table 5.3 shows the codes generated from feelings in relation to air pollution and clean air. Table 5.4 shows the codes generated from motivations for using different forms of transport. And, Table 5.5 shows the codes generated from the measures to be implemented for the transformation to clean air. These tables present the codes, a description of what these codes represent, and the categories which these codes were later grouped into. An in-depth explanation with examples from interviews of the codes and categories is provided in Section 5.3.

Table 5.2 Codes originating from the data transcripts in relation to the two interview questions asking participants to describe air pollution and a city with clean air.

Code	Description	Category	
Sensory **26**	References to experiencing air pollution through the senses, to how it can be smelled, tasted, seen, or felt.	Physical **60**	Description of air pollution **73**
Smog/Haze **18**	References to air pollution being a grey/black smog or yellow haze that can be seen in and around the city.		
Movement **10**	References to air pollution being air that cannot flow, that is trapped in the city.		
Weight **4**	References to air pollution being heavy or oppressive, hanging above citizens, applying pressure.		
Dust **2**	References to air pollution being present in the form of dust on surfaces.		
Dirty air **10**	References to air pollution being dirty air filled with chemicals and particles that are harmful to humans.	Air **10**	

Invisible **6**	References to air pollution being invisible, difficult to grasp.	Invisible **6**	
Green / blue **10**	References to an environment that has blue and green elements, such as trees, parks, rivers, or canals.	Urban environment **27**	Description of a clean air city **45**
People **8**	References to an environment that is designed for people and not for cars, where people can walk and gather.		
Clean surrounding **4**	References to an environment that is free of litter, waste or filth.		
Scandinavia **3**	References to an environment that resembles Scandinavian cities.		
Calm **2**	References to an environment that is tranquil, where people can walk and be relaxed without the danger or noise of cars.		
Fresh air **10**	References to air that is breathable, that is healthy or not harmful.	Air **18**	
Alive **8**	References to air that has life in it instead of particles, as well as wildlife in the city such as birds or butterflies.		

Table 5.3 Codes originating from the data transcripts in relation to the two interview questions asking participants to explain how they feel about air pollution and a city with clean air.

Code	Description	Category	
Worried/concerned **12**	References to feeling worried about the health and environmental impacts of air pollution.	Negative **28**	Feelings air pollution **34**
Angry/Annoyed **10**	References to feeling angry about air pollution towards other citizens, authorities or industry.		
Frustrated / Sad **3**	References to feeling sad that air pollution exists, that humans caused this problem.		
Helpless **3**	References to feeling lost about what to do to reduce air pollution.		
It could be worse **6**	References to other places where air pollution is worse, and to Greater Manchester not being so bad.	It could be worse **6**	
Pessimistic **11**	References to the impossibility of achieving clean air.	Feelings clean air **26**	
Optimistic **8**	References to the possibility of achieving clean air.		
Happy **7**	References to feeling happy about clean air, to being an ideal situation, a dream come true.		

Table 5.4 Codes originated from the data transcripts in relation to the interview question asking participants to explain what forms of transport they use and what their motivations are.

Code	Description	Category
Efficiency **30**	References to arriving on time, travel duration, parking availability, number of connections, frequency of transport.	Motivations for forms of transport **156**
Health/fitness **23**	References to being fit, being active, being in the right mood, mental health.	
Safety **22**	References to safety on the road and feelings of insecurity, as well as safety from crime in the streets.	
Comfort **20**	References to being easy and effortless.	
Pleasure **18**	References to being enjoyable, pleasurable, that makes one happy.	

Weather **16**	References to cold, wind, snow or rain, and appropriate cycling clothing and paraphernalia.	
Cost **15**	References to price, whether it is expensive, cheap or free.	
Environment **8**	References to being environmentally conscious, not polluting or taking care of the environment.	
Disability **4**	References to illnesses or physical conditions.	

Table 5.5 Codes originated from the data transcripts in relation to the interview question asking participants to explain what measures they would take in order to lead the transformation from a city with air pollution to a city with clean air.

Code	Description	Category 1	Category 2	Category 3
Fewer cars **31**	References to fewer cars in the road and parked in the city, to reducing space allocated to cars, and to no car zones.	Car **42**	Transport **115**	Direct factors **185**
Hire / share **7**	References to unnecessary car ownership in favour of renting or sharing a car, and to better organized sharing and renting schemes.			
Electric / Low emission cars **4**	References to electric cars, hybrid cars, or to caps on emissions.			
Improved walking infrastructure **12**	References to improving walking infrastructure and making streets wider, pedestrianisation, and securing space for walking with prams or wheelchairs.	Active transport **34**		
Safe cycling infrastructure **11**	References to improving cycling infrastructure and to make it safer, to bike lanes, no tricky junctions, physical boundaries, showers in workplaces.			
Chris Boardman **6**	References to Chris Boardman and his project for improving cycling and walking infrastructure (Beelines).			
Cycling proficiency **5**	References to making people more competent in cycling as a form of transport, helping find secure routes.			
Network **14**	References to improvements in public transport networks including, frequency, capacity, and coverage.	Public transport **34**		
Price **10**	References to making public transport cheaper or totally free.			
Ease **6**	References to making public transport easier to use, being able to tap in and out in every transport system, or screens with information about services.			
Electric / Low emissions **4**	References to making public transport electric in some routes or hybrid in others, having solar panels in roofs of vehicles.			
Flexible work hours or place **5**	References to being able to work from home or to come and go at different times to avoid daily commutes and rush hour.	Flexible work hours or place **5**		

More green and blue **30**	References to the need for more parks or green elements in the city such as roofs, wall, trees, grass, flowers, rivers, or canals.	Green and blue areas **54**	
Management **11**	References to maintaining green and blue areas and not letting them overgrow, attract antisocial behaviour and become unusable.		
Environmental benefits **9**	References to environmental benefits of green spaces such as reducing air pollution and flooding, or cooling effects.		
Back gardens **4**	References to using back gardens for planting trees and flowers to create a network of greenspace, and to not block pave these for car parking.		
More information **6**	References to the need for more real-time air pollution information, and more information in relation to actions and available alternatives.	Engagement **16**	
Responsibility **5**	References to citizens claiming ownership and responsibility, and to bottom-up approaches.		
Change in mind-set **3**	References to changing the way people think about convenience and material wealth.		
Hubs **2**	References to the power of workplaces, universities or schools in encouraging change.		
Litter **16**	References to cleaning the streets from litter and waste, and to creating pleasant environments for walking.	Pleasant spaces **25**	Indirect factors **66**
Homelessness **9**	References to sorting out homelessness and drug use, and to creating pleasant environments for walking.		
Community **17**	References to creating strong communities to benefits for citizens and the environment.	Community **17**	
Health **15**	References to how greenspace and active forms of transport improve fitness, well-being, and have therapeutic effects; and how healthy people are more likely to appreciate and care about the environment.	Health **15**	
Safety **9**	References to the need to create a city where everybody feels safe, and to spaces that feel unsafe.	Safety **9**	

Although coding is widely used as a process for data analysis, there have been methodological objections to it. Two of the most salient criticisms associated with coding are that it is reductionist and that it distances the researcher from the data (Coffey and Atkinson, 1996; Saldana, 2009; Bryman, 2012). This study subscribes to the widely acknowledged counterargument that, looking at it holistically, when codes are employed to form patterns that bring the multiple voices of the participants together in one narrative, coding is not reductionist. Furthermore, in agreement with Saldana (2009) coding does not distance a researcher from the data but brings them closer together. A code, a word that is chosen so carefully

and meticulously, requires spending long periods of time understanding the data. As Saldana (2009) argues, it is often the case that a researcher remembers not only all of the assigned codes, but also the exact words and phrases used by the participants under that code.

5.2.5 Assessing qualitative research: trustworthiness

The criteria for assessing a qualitative study differ from the criteria commonly applied to quantitative research. Trustworthiness appears then to replace validity and reliability as these cannot fully encompass the nature and nuances of qualitative research (Guba and Lincoln, 1994; Hsieh and Shannon, 2005; Bryman, 2012). Trustworthiness can be explained as a set of criteria (comparable to those in quantitative research) for assessing a qualitative study: credibility, transferability, dependability, and confirmability (Guba and Lincoln, 1994; Hsieh and Shannon, 2005; Bryman, 2012).

Credibility is related to the fact that there can be multiple constructions of a reality and that the account of the reality that the researcher describes is accepted by others. A common practice to assure credibility is to obtain respondent validation, that is, to share the findings with the selected sample and confirm that the researcher has correctly understood the situation (Guba and Lincoln, 1994; Bryman, 2012). The findings of this study were validated with a representative sample of the participants involved – 10 participants with different backgrounds who agreed to meet again for an informal discussion of the themes and suggested interpretation.

Transferability is related to the fact that qualitative research is about depth rather than breadth, and hence the difficulty of claiming that the findings are representative of a whole population. In qualitative research, it is important to produce a “thick” description, that is, rich accounts of the setting of the study so that this can facilitate comparisons between studies of different populations (Guba and Lincoln, 1994; Bryman, 2012). In this case, the methodological approach adopted in this study (i.e. interview style, interview guide, or coding

process) to explore the experiences and ideals of one particular group in society can be transferred to other contexts worldwide. Furthermore, the findings themselves could be transferred to other similar contexts: developed urban environments where unpaid work, economic inequality, and perceptions of fear shape the experiences and perceptions of women.

Dependability is related to carefully showing all the steps and procedures that have been adopted during the research. It is a similar process to auditing, where all the materials employed are made available to others. In this research, the interview guide can be found in Section 5.2.2 of this chapter, the code book has been presented in Section 5.2.4, the transcript of the interviews have been made public in a repository, and the participants' voices are presented alongside the codes and categories in the section that follows (Section 5.3) (Guba and Lincoln, 1994; Bryman, 2012).

Confirmability refers to being subjective but rigorous. That is, even if objectivity cannot be achieved, the research is rigorous in its analysis, and the personal values and world views of the researcher do not influence the outcome (Guba and Lincoln, 1994; Bryman, 2012). In this study, this can be assessed externally as the data collection and analysis processes have been explained and made transparent (e.g. through the code book). The fact that respondent validation was sought also further supports the confirmability of this study, as objectivity is given when participants corroborate the findings (Ibid.).

5.3 Findings: the voices of women

This section presents the findings of the qualitative interviews structured in relation to the themes originating in the coding process. A theme is a phrase or sentence describing a trend based on the codes and categories generated in the data analysis process (Saldana, 2009). If a study has a high number of codes and categories, themes should be kept to a minimum, somewhere between three to seven, so that the analysis is "coherent" and the reporting of data "elegant"

(Saldana, 2009:24). For example, the codebook in Section 5.2.4 showed how three categories emerged from the codes assigned to how participants described air pollution (Table 5.1): as something PHYSICAL (60 mentions), as harmful AIR (10 mentions), and as something INVISIBLE (6 mentions). The theme that originates from this is that 'air pollution is physical' rather than something invisible, intangible, or ungraspable in the way it has often been depicted in the media or the literature (Defra, 2017; EEA, 2017; WHO, 2018). Themes can be viewed as short conclusions or highlights of the dominating aspect.

In order to make the participants voices stand out and to give credibility to the interpretation of the data presented here, verbatim quotations from interviews are presented (Bryman, 2012). The pseudonym chosen by the participants for anonymity is presented alongside the quotes.

As mentioned earlier, participants believed that overall, as well as individually, transport was the sector that contributed to air pollution the most, followed by households (heating and energy), industry, and agriculture. Therefore, these findings suggest that transport plays a major role in how air pollution is conceptualized by the participants.

5.3.1 Conceptualizations of air pollution: it is physical

In interviews, participants described air pollution as something that is physical, that can be felt with the senses: air pollution can be smelled, tasted, felt, and seen. People who commute by bike or foot as their main form of transport explained how fumes emanating from cars is often blown in their faces, and how they can smell it or even notice a “stale” taste. They also discussed feeling air pollution in their throat as a “tingling” sensation, or in their lungs affecting lung capacity and that these organs were not able to “expand” fully. They also explained how living in a city with air pollution turns their “snot black”. Participants described air pollution in relation to lack of movement; they referred to it as air that cannot move or flow, air that is “trapped” between buildings in a city, that “hangs” over a city and its people. Consequently, air pollution was sometimes talked about in

relation to weight; air that is “heavy” and dense. This relates to the aforementioned idea of a lack of movement in the sense that the air gets trapped in the city and feels “oppressive” for its citizens, i.e. they can feel its weight. Air pollution was also described as dark smog or yellow haze. Sometimes in relation to car exhaust fumes that can be seen in the city, but most commonly people who hike to Lyme Park (located in the Peak District and adjacent to Stockport (postcode SK), one of the boroughs in GM) described looking back over Manchester and being able to see a “yellow haze” over the city. Finally, in some instances air pollution was described as dust. Participants talked about it as common dust in the household but sometimes emphasized that it is not “just” dust, referring to harmful components. But in practical terms, participants saw it as dust and reported that the more air pollution in a city, the more often their house requires cleaning. Participants appeared surprised by how quickly the dust enters the house.

> … [in the Swiss Alps] the air was clear and it had this pure feeling to it you could breathe in and it felt like your lungs were endless because there was nothing blocking you… and here when I breathe in the air it's like it hits a wall within my lungs and it doesn't taste so pure it almost has kind of like a stale taste to it… (Asta)

> … the air not being able to flow… if the air can't flow it's stagnant so we get it over a city… it seems to hang… … it can feel quite oppressive… (Moggie)

> I can dust one day… and I open the windows and the dust that comes in is unbelievable… it’s just dust isn’t it… well not just dust… (Ruby)

On fewer occasions, air pollution was described as dirty air, that is harmful for any kind of life, humans, animals, or plants. It is described as an air that contains harmful things in it, such as chemicals, particles and toxins; things that can’t be seen by the human eye.

> …I suppose it's the toxins in the atmosphere they have a negative impact upon people, animals… (Newcastle)

And finally, in a few instances air pollution was referred to as invisible (as opposed to the conceptualization of air pollution being physical), as something that exists but is impossible to see which makes it difficult to grasp or care about. Participants explained how it can only be seen on extreme occasions, in large cities like Tokyo or Manila.

> … I think because you can't see it as such… it's not something that's tangible… it's not like when you kind of walk somewhere and see a load of rubbish… so that you kind of feel quite affected by it… whereas air pollution… I don't think you necessarily know it is having an impact on you so I suppose… so I guess in that sense it's invisible to most people… (Grey)

5.3.2 Conceptualizations of clean air: the air is breathable and alive, the urban environment is clean, calm, green, and for people

When participants were asked to describe a future city with minimal or no air pollution, they sometimes talked about the air as being fresh, breathable, and of containing creatures rather than chemicals; but most often participants discussed the urban environment itself. They talked about elements they believe come hand-in-hand with clean air, such as greenspace. In other words, participants also described the elements that an urban environment needs to have as a prerequisite for clean air.

Participants described an urban environment that is green and blue. If the air is clean, then the urban environment must be green and blue. They envisioned a place filled with plants, trees, gardens, green buildings, rivers, etc. They also described a place that is for people rather than vehicles. When participants pictured a city where the air is clean, they saw people walking about, spaces to meet, cafés to gather in, and green areas where people can spend time outdoors. They also mentioned clean surroundings. Not just clean air, but clean streets and

neighbourhoods. A pleasant and pretty environment free of litter. Participants also explicitly described Scandinavian cities, such as in Norway or Denmark, where cycling is an important form of transport. When participants described these urban environments they sometimes said that they were just describing a Scandinavian city. This urban environment was described as calm; a place where people can walk slowly and where there is no tension or noise produced by cars.

> I think about water… trees… fields… like a lot of green and blue… green and blue everywhere… (Alzaor)

> it's a place where people can actually walk, and sit, and interact… it's got benches, it's got activities, it's got people… (Sarah)

In relation to air, participants discussed fresh air and the air being breathable. This description relates to when air pollution was described as something that can be smelled, felt, seen, or tasted. With fresh air these experiences disappear and the lungs can expand and do not feel tight. They also described the air as being alive. An air filled with life, with creatures and animals rather than chemicals or particles.

> It's just an air that's easy to breathe… there's no fumes and you don't feel it on your chest… (Newcastle)

> the air should be full of creatures rather than particles… (Blue)

5.3.3 Feelings towards air pollution: worried, angry, sad, and helpless

Participants discussed negative feelings, they appeared worried or concerned that the damage that air pollution is causing cannot be fully seen or experienced right now, and that the consequences might be more severe than predicted. They were concerned for their children and for the more vulnerable people in society. Participants also reported feeling angry or annoyed about air pollution. Their anger or annoyance was directed at someone, either people in general because they do not care sufficiently, or politicians and government as they are not doing

enough to tackle it and see it as a political issue over a health emergency. Participants used strong language such as “it sickens me” as can be seen in the quote from ‘Blue’ below. Other participants felt frustrated or sad. Sad that humans were able to cause this, to behave in such a way that leads to “killing” people and the environment, and frustrated because not enough is being done. Some participants also explained feeling helpless, that is, not knowing what to do or whether our actions as individuals can help improve the situation. They explained how they have discovered that actions that they had taken in the past out of concern for the environment were later found to be very negative, such as diesel cars, or how wood burning stoves that seem so natural can in reality have negative effects.

> … there was an article on the news this morning about air pollution and the fact that it affects older people more than younger people which obviously I'm concerned about… I do worry about it a lot… (Madrid)

> I'm angry… I'm angry that like this is a problem… well that it could be a political issue rather than a public health emergency… it’s just a failure of various levels of governance but also it sickens me that politics would be more important than people's health, children's health…. And yeah that makes me angry… (Blue)

In fewer instances participants felt that it could be worse. This was especially the case for those participants who have lived in larger cities or who were originally from other countries such as China or the Philippines where air pollution is more severe. These participants said that although air pollution might be a problem in GM, it seemed very mild in comparison to the situation in other cities they have lived in. Older participants also explained how they didn’t think it was as bad as it used to be in the past.

> … Manila yeah… it's because of that kind of you know reference point I feel like this is not bad you know… I know that it's… that it's not ideal still… (Dailyrunner)

5.3.4 Feelings towards clean air: mainly pessimistic

When participants were asked about how they felt about an urban environment with clean air they discussed feeling more pessimistic than optimistic that an urban environment with clean air can be achieved. Most participants argued that there is no political will or bravery to change, that citizens do not care and do not do enough, and that there is no vested interest for industry in supporting the change that is needed. On the other hand, some participants believed that society is on the right track and that if everybody collaborates it can and it will be achieved.

> Things change the quickest when there's commercial vested interests in making them change and with air pollution I don't think that there is… so unless you have a powerful government who legislate to change it it's not going to happen… (Popcorn)

> I have travelled in the world and you see places that feel a lot greener, cleaner, the air is clearer… you know so I think yes you can… (Sarah)

Participants explained feeling happy about the possibility of living in a place where the air is clean and found themselves smiling while picturing this scenario.

> That would be a lovely thing to have… I'd be very happy if we had a carbon print of zero… that would be a dream come true yes… (Asta)

5.3.5 Conceptualizing active forms of transport: health, well-being, and pleasure are key

In interviews participants were encouraged to think about their motivations when choosing a form of transport. This resulted in a series of factors that participants explained to act as catalysts or deterrents of a particular form of transport. An overview of these motivations can be found in Figure 5.2.

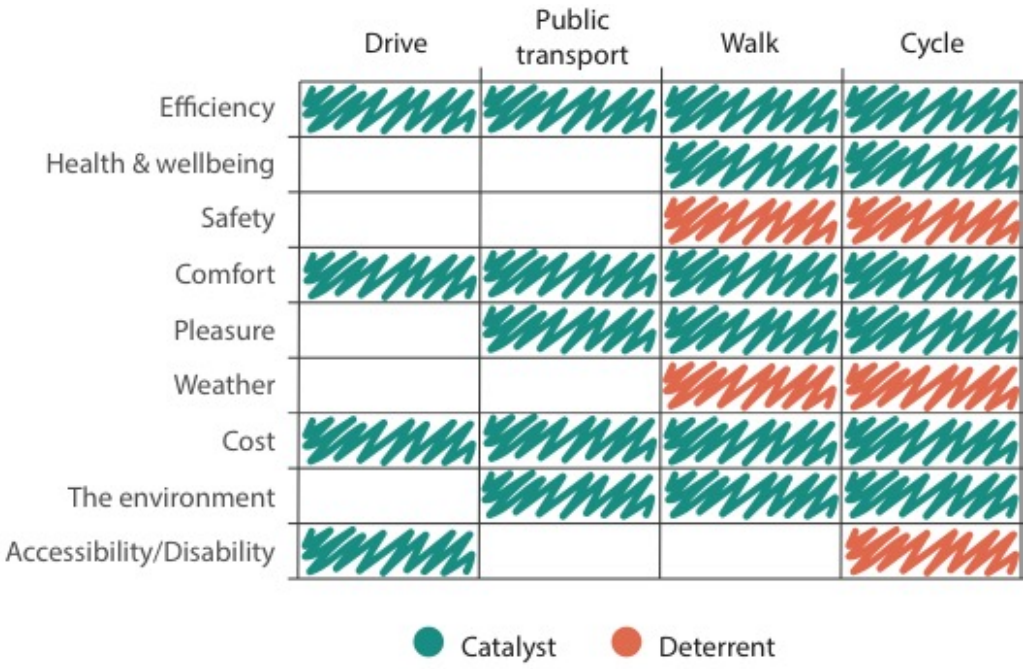


Figure 5.2 Catalysts and deterrents of four different forms of transport (driving, using public transport, walking and cycling) as experienced by its users.

Efficiency was the most widely discussed, among car drivers, cyclists and public transport users alike (Figure 5.2). Car drivers explained how it would take too long to commute by public transport adding to already long working days, or how they did not live near enough to a bus or tram stop. They discussed the hassle of having to rely on timetables and how the car allowed them to come and go at their own convenience. In interviews, the car appeared to be a good option for women with children that needed to be escorted to different extracurricular activities often requiring multiple stops. The idea of not relying on timetables was also discussed widely by cyclists. They often talked about the freedom of the bike. Beyond this, cyclists said that they believed they had an advantage over car drivers as they can avoid traffic jams. Cyclists explained being able to enjoy the benefits of the road or in becoming a pedestrian when road conditions are not appropriate. Efficiency was also discussed as a motivation for using public transport. People who rely on public transport believed it to be an efficient way to get around. This was mainly discussed in relation to trams (instead of buses) as there is no congestion for tram passengers. Public transport users also explained how public transport was more efficient than driving as they did not have to worry about finding a parking space. The efficiency of public transport was not only discussed in comparison to driving,

but also to walking. Sometimes participants explained how they did not have the time to walk long distances when commuting between home and work.

> Because it's convenient… I also drive because I have got family stuff to do… so I have two teenagers that I ferry around so whether it be for football, horse-riding, or whatever picking them up… and I'll do it… I live about 20-minute or 25-minute walk to the nearest Metrolink stop which is Altrincham… and I just don't have the time… When you work full time and you've got two teenagers…. (Suki)

> Don't like waiting around for buses… and I want to know I'm going to be on time to wherever I'm going so I can rely more on my bike than I can on public transport… (Popcorn)

> … the choice to just take a bus it's the time obviously… I mean you know I can't spend another two hours walking back… (Dailyrunner)

Health and well-being were also widely discussed, particularly among those who cycle or walk (Figure 5.2). Participants discussed how walking was good for their heart and overall health. They explained how walking and cycling kept them fit, and how it was an easy way of incorporating exercise into their daily routines without much effort or consideration. People who cycle as their main form of transport discussed how they believed they get sick less often. Participants also talked about how walking or cycling were beneficial for their mental health, as it helped them cope with stress, and with workdays that could be long and intensive. Walking and cycling were experienced as an opportunity to get mentally prepared for work or to unwind after. In a few instances, participants who rely on public transport also discussed these benefits in the walks that are required to and from the bus or tram stops at both ends of their journeys.

> I don't have really any time to go to a gym or do a regular sport, but if you're using your traveling time to get your exercises, instant bonus… (Porpcorn)

> Cycling helps me unwind actually… when I'm doing either walking or cycling that's what I'm doing… if I'm coming to work on my bike it helps me kind of set myself up for the day… then on the way home it kind of helps me empty my brain… (Ruth)

Safety was widely discussed primarily by those who cycle or walk (Figure 5.2). There were three types of discourses in relation to safety: safety in relation to having a bike stolen, road safety while walking or riding a bike, and safety in relation to being physically or sexually assaulted when walking. First, participants discussed fears of having their bike stolen. They explained how they have to consider parking options at their destination, i.e. whether it is a safe area or whether they can lock their bike properly. They explained how going to an unsafe area and fearing having your bike stolen could be translated into finding alternative forms of transport. Second, participants discussed not feeling safe when cycling on the road. They explained that there are not enough cycling paths and when there are, these are not well maintained or clear-cut. Roads are described as being bumpy or riddled with potholes. These type of safety issues were discussed by people who cycle regularly and who are able to notice unsuitable cycling paths and roads. Interviewees who do not cycle showed a more general and unsubstantiated feeling of fear in relation to cars. The regular cyclist explained working out the best routes and finding less busy or less dangerous roads. The feeling of insecurity in the case of regular cyclists is accentuated when they travel with children. Participants explained how since they had their children they thought twice about what roads to take or even whether to cycle in the first place.

> I feel a lot less safe… my yeah…. my evaluation of risk has changed since I have my daughter… like how I ride has changed…. the routes I'm prepared to go… helmet wearing… (Blue)

Third, participants discussed safety in relation to being sexually or physically assaulted. These fears were particularly acute after dark. They discussed how their strategies to overcome this fear included either arranging to walk with someone,

changing the form of transport to, for example, a taxi, or avoiding the trip altogether.

> I think the safety thing is really tricky for women… where I live now is maybe about a 10-minute walk [from the tram stop] and the road is very quiet so I think twice about when I'm going out… I wouldn't do it on my own now… I'm usually with my husband and if not I tend to stay in… because I won't do that walk at night… (Billy)

Comfort was discussed in relation to the car and public transport, but not in relation to walking or cycling as there were other more prominent benefits tied to these forms of transport, such as health benefits (Figure 5.2). Participants explained how the car offers a door-to-door service, how it is the simplest option when children are involved, and how it is more comfortable when they run errands or go shopping and have to carry heavy bags home. Participants who found public transport more comfortable than driving explained that they disliked driving altogether or they found it tiring or stressful. Public transport allows them to disconnect, read, or have a conversation. They also explained how public transport has improved considerably and there is now space for prams or wheelchairs, which makes it a more comfortable experience.

> If you're going to carry a lot of things for me it's much easier to put them all in my car… than carry them with my hands everywhere… and it's much comfier… (Alzaor)

Pleasure was also discussed by people whose preferred walking, cycling, and to a lesser extent public transport (Figure 5.2). Walking was talked about in terms of pleasure the most. This was seen as an opportunity to wind down after work, make a phone call, discover new routes in the city, or see green areas and geese along the canals of GM. Walking was an activity that participants enjoyed doing. Cycling was also seen as pleasurable, it makes people happy. It also allows going off-route and enjoying the sites or the change in seasons. Furthermore, when participants discussed how walking and cycling were pleasurable they became very passionate

about it. Some participants believed public transport is pleasurable as it can be combined with reading or enjoying a coffee.

> I like the fact that I can go off road [cycling] which means I can see the seasons change… I get to see foxes, squirrels, get to listen to birds tweeting… it's just so much nicer (Tullyrusk)

> I do enjoy walking because you listen to music or a podcast… especially walking along the canal looking at the geese… it relaxes me… (Plat)

Participants who talked about the weather to a greater extent were those who cycle on a regular basis (Figure 5.2). Some of the participants explained how they just came to terms with the characteristically rainy weather in GM, and how they have equipped themselves with waterproofs and the right spirit, to the point that cycling in the rain fills them with endorphins. Other participants explained being weather sensitive and only enjoy walking or cycling when the weather is nice. Some stated choosing different forms of transport in different seasons: walking or cycling in spring and summer, and using the car or public transport in winter. In some instances, participants recounted cycling in the rain when on their own, but admitted changing their routine when travelling with children; they explained how cycling when it is cold or wet is not as easy when children are involved. Women who walk also reflected upon the fact that they would not walk long distances in bad weather if they are escorting children.

> … this morning it was raining really really heavily I got absolutely soaked but I loved every minute… I'm just like endorphin filled…. (Tullyrusk)

> So for me I would basically cycle 99% at the time if I didn't have my daughter… but so when I've got her with me…. I'm a little bit more sensitive to the weather…. there's quite a lot of stuff involved in cycling in that weather just for a person on their own let alone like this little kid who's going be complaining…. (Blue)

Cost was another factor, most often referred to by those who walk or cycle as for them travelling is free (Figure 5.2). Those who use public transport on a daily basis and hold pensioner, student, or monthly passes also explained that public transport is cheap. Not having to pay for parking was another factor discussed by those who preferred public transport over the car. Fewer instances associated the car to a cheaper form of transport. This took place in the case of families when a full occupancy car can be cheaper than public transport for all. In contrast to frequent public transport users who hold special passes, people who owned a car and used it as the main form of transport thought public transport was expensive.

> Maybe economic reasons… I don't have to spend anything to walk… (Snehvide)

On some occasions, participants who commute by foot, bike or public transport explained thinking about the environment when choosing a form of transport (Figure 5.2). This often happened in combination with other reasons, as participants explained how walking is good for their health and additionally for the environment, or how cycling is free and does not contribute to air pollution.

> I live near enough to the local shops and amenities to walk so I always walk and that's about not taking journeys I don't need to take… (Sarah)

On fewer occasions, permanent, intermittent, or passing disabilities were discussed, such as back pain or anxiety which stopped participants from being able to cycle or take public transport respectively. In these cases, they reported a dependency on the car (Figure 5.2).

> I have a back problem which limits quite a lot of the exercise I can do… so I can walk but I can't cycle because I can't get into the positions to do it… (Grey)

5.3.6 Envisioning a city with clean air: pleasant and safe spaces are as important as an improved transport system

In addition to describing an urban environment with clean air and how this place made them feel, participants were asked to explain what measures they would put in place or what actions they would take at a city level to lead the transformation to clean air. Participants discussed a series of factors that they believed would result in an urban environment with clean air. Some of these factors were directly linked with air pollution, such as reducing the number of cars, which if implemented would result in improvements to air quality. Other factors participants discussed were indirectly linked to air pollution, such as reducing the amount of litter on the streets. If implemented they would create more pleasant streets that invite walking instead of driving, and would then indirectly tackle air pollution by creating the right conditions for change. In other words, in order to reduce air pollution, participants believed that there is a need to address factors such as transport by reducing the number of cars and improving cycling infrastructure, but also to improve the appearance of the city by making it greener (e.g. planting trees), cleaner (e.g. tackling the litter issue), and safer (e.g. for women, children and everybody else).

In relation to directly linked factors participants discussed three areas of action: (1) an improved transport system, (2) improved green and blue spaces, and (3) better and more abundant information and communication.

In relation to transport, participants talked about cars, active forms of transport, public transport, and flexible work schedules. In relation to cars, participants not only discussed the need for fewer cars, but even suggested pedestrianizing the city centre and urban centres in all the different boroughs across GM. When prompted to think about solutions for people to be able to get to a pedestrianized city centre, participants discussed improving transport links (which will be discussed in the paragraphs below), but also better and cheaper parking spaces outside the city centres. Participants also suggested improving car sharing or renting schemes. They explained that if renting or sharing a car was easier, and

that if a car could be summoned quickly when needed, the perceived need to own a car would disappear. Electric cars and low emission vehicles were also discussed as necessary solutions. Participants believed more charging points and longer lasting batteries are needed, as well as incentives to encourage their use.

> I suppose if you took cars away from the city centre… you would remove a lot of the things that people would immediately notice… like the noise… like the fumes that are obviously coming out of cars… and just the physical presence of a car that you've got to be alert to be crossing a road… (Grey)

> Do people need cars if you live in a certain vicinity? So maybe more availability to hire a car… (Moggie)

In relation to active forms of transport, participants discussed the need for improved walking infrastructure. They explained how streets should be wider and how there is a need for more pedestrianized areas. They described that, often, streets are used for cars to park making it very difficult for people to walk on the pavement, and making it unsafe for people with prams and wheelchairs. Participants also discussed creating safe cycling infrastructure. They suggested having more cycle paths as well as clear-cut separation from the road. They also talked about the state of the roads and how they are bumpy or full of potholes. They explained how cycling should be an activity for everybody and not only for those who are willing to take risks. Participants believed that fewer cars on the roads would automatically make this form of transport safer. In relation to cycling, participants also believed in the need to invest in cycling proficiency. That is, teaching people how to behave amongst cars, and helping people find routes that are easier for beginners or less confident cyclists. One of the participants disclosed how a radio programme made her more confident on the road and encouraged her to claim space among cars, as she found out that female cyclists ride closer to the curb and how this makes cycling more dangerous. Participants also talked about Chris Boardman – a British Olympic gold medal-winning cyclist and GM's first ever Walking and Cycling Commissioner. Although he has no official qualifications when it comes to planning, participants trust him and believe in him and in his Beeline project (TfGM, 2018) that aims at improving the city's walking

and cycling infrastructure. Even participants that were sceptical about the current planning system and policymakers generally talked highly of Chris Boardman. They used words charged with emotions such as being “excited” about his project. They described him as being “amazing” and having “my heart set” on him.

> Space to move around… because at the moment I feel like my experience of the urban environment is like shuffling along the pavement like this [gestures squeezing past in a narrow space] … squeezing between like a wall and a car that someone has parked two wheels or four wheels on the pavement… (Blue)

> And the bike lanes you can’t rely on them… they just sometimes lead to nowhere… and the number of potholes… (Violet)

> I've got my heart set on Chris Boardman… it's going to be amazing… (Tullyrusk)

In relation to public transport, participants explained how there needs to be an improved network. There needs to be an interconnection with the city centre but also across boroughs. They also believed public transport should be more frequent, less crowded, and more reliable, and discussed how public transport could be made cheaper or free as this would immediately reduce the number of cars on the roads. Participants also explained how there should be a ‘maximum day spend’ that allows a combination of multiple transport systems. Participants also talked about electric or hybrid vehicles when it comes to public transport. They explained that some routes that are longer or steeper might not allow for electric cars, but that in those cases hybrid buses could be a solution. They also discussed the alternative of having permanent solar panels in the roofs of buses. And finally, participants believed that public transport should be made as easy as possible to use. They mentioned aspects such as digital screens with up-to-date timetable information, or being able to tap in and out with contactless payment across all public transport services.

> It isn't as easy to get from one borough to another… you really kind of have to go into the city centre and back out again… so more investment in good buses… (Newcastle)

> The first thing I would do is… if I had all power… I would make all public transport free because I think that would just take so many cars off the road and that would have a massive impact on itself... (Tullyrusk)

Another factor that participants discussed in relation to improving transport, especially with regards to congestion, freeing the road for cyclists, and making space for pedestrians, was implementing flexible work hours and places. That is, the freedom to work from home if the work does not require meeting face-to-face, and allowing flexibility in relation to start and finish times.

> I think yeah looking at working patterns it's a big thing… the idea that you get everybody to turn up at nine o'clock… you've got this massive influx of traffic and demand on trains… (Grey)

In addition to transport, participants also highlighted the importance of green and blue spaces, and discussed how more green areas are needed across GM. This is in line with participants' conceptualisation of a city with clean air, where the air is breathable and alive, and the urban environment is clean, calm, green, and for people. They acknowledged that it can be difficult to create parks, but they suggested including green elements and flowers in different areas of GM, in other words, creating a network of green areas or elements. They talked about more trees, vertical gardens, green walls and roofs in buildings, and generally greening every unused surface. They believed pedestrian areas should not all be block pavements and instead saw these as an opportunity for green places. They also talked about an even distribution of green areas, and how more attention should be paid to greening those more rundown areas in GM, and discussed properly maintaining green and blue areas. They explained how some green areas are too wild for pedestrians and people to use and how they end up attracting antisocial behaviour and become scary places. Similarly, participants talked about the city's multiple canals and how they are dirty and unsafe places. They also discussed how

there is a tendency to block pave all the backyards and entrances to houses and turn them into private parking spaces instead of having back gardens. Participants suggested more attention should be paid to potential greenspace and to having plants, trees and flowers that can help in making the area greener and also in cleaning the air. Participants were very passionate about green and blue areas and discussed a multitude of environmental benefits associated with these spaces. They explained how they can help in cleaning the air, managing floods, or providing shade and creating a cooling effect.

> Piccadilly Gardens with that horrible wall that if you look at it from the air apparently it means something… but who looks at it from the air? we really lack greenery in this city… (Suki)

> Make the canal network more inviting… assets that already exist but aren't being utilized as they could be… the canals aren't maintained properly… a bit overlooked… a bit of anti-social behaviour… (Ruth)

In relation to information and communication, participants discussed the need for more information. Information that addresses very specific actions that citizens can take rather than just broad information about how severe the air pollution problem is. More information on car sharing schemes, what forms of transport are better, what routes to take as a cyclist, etc. They also agreed on how real-time air pollution information would help in raising awareness. Participants also mentioned that citizens need to take more responsibility. They believed citizens need to take more ownership of their actions and their consequences and have a willingness to change their lifestyles, including aspects such as the way they get around. They believed there is a need to break away from thinking that air pollution is somebody else's problem, that it is not just a problem for governments or councils to deal with. They discussed how citizens need to claim ownership and take the lead. They also reflected on the need for a change in mind-set. A change in relation to material wealth and possessions; moving towards a mind-set that understands sharing and renting as more favourable than owning. They also talked about a change in what people understand as convenient, rethinking what convenience is or learning to live with inconvenience. Participants agreed that a

good way of sharing information and instigating change is by working with hubs, such as schools, universities, companies, etc. to, for example, encourage people to commute differently.

> those electronic boards that give you information too… you know how you got like speed limit values… so it could be vehicle emissions… (Cleanairbex)

> I guess there has to be a change in mind-set so that being less comfortable isn't perceived as being less comfortable… (Ruth)

In relation to indirectly linked factors participants discussed four areas of action:

(1) creating pleasant spaces that invite walking,
(2) creating a community feeling that makes people care about others and the environment,
(3) creating safe places, from road accidents as well as from crime; and
(4) creating healthy places where people value their well-being as well as that of the environments.

Some of these such as creating pleasant and safe spaces are linked to direct factors, such as more greenspace that are well maintained, that prevent antisocial behaviour from concentrating there, and which do not become isolated.

Participants also discussed the importance of pleasant spaces in shaping behaviours. They explained how litter creates unpleasant streets and neighbourhoods that do not invite walking or spending time outdoors. Participants also explained how they saw homelessness as an issue, how it degrades the image of a region, and how it contributes to unpleasant streets. Although they discussed how homelessness and drug addiction can devalue a place and make it more unpleasant, they did not talk about it in terms of moving homeless people out of sight, but of how society as a whole should be better at tackling this problem and at "looking after them" if they are unable to work or live on their own.

> But it’s so filthy… so obviously, that puts people off… If you start to think about, like you know, a clean environment and then that could potentially make people be more keen to walk and, you know, maybe cycle… (Dailyrunner)

> So we don't have people on the street, homeless people… Because it's a visual thing… Piccadilly Gardens… a lot of people with alcohol, drugs, hanging out even during the day… (Suki)

Participants discussed the need for spaces that facilitate creating bonds with community members. A feeling of belonging or a community feeling in their views could be translated into caring about others, and in turn caring about the place where you live, the environment, and air pollution. According to participants, when people care about the place where they live and the people who live in it, they are more likely to treat it nicely and not let it deteriorate. Participants explained how caring about other people can also in turn be translated into a greater sharing culture, which links to the previously mentioned aspect of an increase in the number of shared car journeys. Similarly, according to participants, communities have knock-on impacts so that the pressure that a community places on the individuals of that community can make them change their behaviours, such as encouraging them to walk or cycle more.

> If you have a strong community… they have a place to go… and they will automatically start taking care of that place. So the greenspace that you create initially becomes self-sufficient because there are people enjoying the greenspace, they don't want to lose it, and they will automatically take care… (Asta)

> I moved there I wasn't really thinking that much about the environment or things around recycling and things like that but when you move there you just kind of… you can't help it… everybody else is doing it… your friends are cycling to work so you just naturally start thinking about it… (Billy)

Health was also at the forefront of these discourses. Participants explained how green and blue spaces not only have environmental benefits but also social ones. They explained how green and blue areas improve the mood, well-being and mental health of its users, inviting play, running, and sports practice. Interviewees also believed that improved cycling and walking infrastructure would make people more active and foster a fitter society, reducing health issues such as obesity. Participants reiterated how healthy people who enjoy the outdoors are more likely to care about the environment and air pollution.

> Not only does it help clearing or cleaning the environment, it also makes a positive impact on people, you know… you feel better when you see some flowers and… when you feel better you can be more… you can be kinder… and you are more open to the idea of actually taking care of your environment… (Asta)

Safety was also an important part of participants' discourses. They discussed the importance of feeling safe when walking and cycling. Not only in terms of road accidents, but also in terms of the fear of being physically and sexually assaulted, or of crime more generally. In their views, well-maintained green and blue areas, as well as urban environments that are designed for people can help in eliminating or reducing feelings of insecurity.

> That's because of my perception that it's not safe because there's not a lot of people there … it's like if you can create more people walking then it makes a more vibrant place and it makes it safer for everybody else… (Billy)

> I know people who live close to me but they take a bus to go to the same place I go… they see that the canals are not nice… don't look safe… (Plat)

5.4 Discussion

Air pollution is a global challenge affecting people, the environment, and the economy. The experiences of air pollution are constructed by citizens who are both sources and victims (Xu et al., 2017). Different people in society have different constructions of air pollution based on factors such as gender, income, values, or preferred forms of transport (Bradley, 2009; Kaijser and Kronsell, 2014). This study has focused on women specifically and, through qualitative interviews, it has explored their experiences of air pollution, their motivations when it comes to mobility, and their views of an urban environment with clean air. Content analysis was applied to these interviews and, through a process of coding, key themes were identified; themes that can inform the framing of communication and structural changes so that these are met with public support and acceptability. This study is not concerned with the likelihood of the scenarios described or of the effectiveness and prospect of the measures suggested. These findings are about understanding public perception and uncovering the mental frames – i.e. mental infrastructures that are used to organize knowledge and to guide and accommodate new information (Lakoff, 2010), which can in turn be used to think about air pollution and clean air, and through which new information and policies will be processed and evaluated.

In terms of findings, these interviews show that air pollution is not as invisible as it has been described in the literature, often referred to as an invisible killer or silent threat (Defra, 2017; EEA, 2017; WHO, 2018). Participants described it to a very great extent as something that can be seen, smelled, tasted, and felt. Perhaps air pollution has been described as something invisible because the voices of women, who spend more time outdoors and which has proven to influence the experience of air pollution (Garcia-Ramon et al., 2004; Buckingham, 2016), have been invisible themselves. In describing a city with clean air, participants gave more attention to the physical environment than the air itself, perhaps also because women are more tied to the local environment and make greater use of it (Johnsson-Latham, 2007; Madariaga, 2016b). They described clean air as being breathable and containing life, such as full of creatures instead of particles.

However, greater attention is placed on describing a green urban space with no litter, as well as a place that is designed with people in mind rather than cars. These descriptions have important implications for communication. These discourses highlight that it is possible to leave aside the unengaging discourse of air pollution being invisible, focussing instead on the physical ways in which air pollution can be experienced. Furthermore, these discourses suggest that talking about the air itself is rather difficult and that conversations should instead be linked to physical urban spaces, stressing its green, pleasant, and safe qualities and the multiple benefits it brings for citizens.

These findings show that participants are aware of the air pollution problem and that it generates negative feelings of concern, frustration, anger, and hopelessness. In turn, participants feel pessimistic about the future and about the likelihood of a city with clean air. Chapter II reviewed the literature on communicating through emotions and feelings in relation to climate change to discover that fear 'won't do it' (O'Neill and Nicholson-Cole, 2009; Mir et al., 2016). The literature suggests that highlighting the problem rather than the solutions has proved to be ineffective, paralysing people rather than motivating them to adopt positive behaviours (Kollmuss and Agyeman, 2002; O'Neill and Nicholson-Cole, 2009). The findings from these interviews appear to support these previous studies, and suggest that more positive discourses on air pollution are needed, highlighting behaviours and measures for citizens to adopt, as well as the multiple benefits that these behaviours, in addition to clean air, will bring about for people and the environment.

Although these findings show negative feelings and pessimistic accounts, participants can become very passionate about the future or about particular aspects of the present. This is the case when referring to Chris Boardman and the Beelines project to improve walking and cycling infrastructure. Boardman is a British Olympic gold medal-winning cyclist who, in 2017, was appointed GM's first ever Walking and Cycling Commissioner. Although Boardman has no formal qualifications when it comes to planning or policymaking, he is seen as highly trusted and inspiring. This too has important implications for communication: opinion leaders can be key in shaping structural changes and motivating

behavioural changes at the individual level. This aspect is also related to findings in Chapter IV and III. Chapter IV showed how governments are not perceived to be very trustworthy and how the literature suggests that the messenger is as important as the message itself (Mir, Behrang, Isaai, & Nejat, 2016). Similarly, Chapter III showed that a key element of educational programmes, where a genuine dialogue is established between the public and the experts, is the role of trusted opinion leaders (Moreno Ramírez et al., 2015). This also links to the participants' suggestion of employing hubs to change behaviours. Participants explained how trusted colleagues or teachers can be key in motivating behavioural changes in workplaces, universities, or schools.

In discussing motivations for using different forms of transport, participants who rely on the car as their primary form of transport appeared to be driven by comfort and efficiency. It follows then, that measures to make car usage more difficult such as reducing road space or pedestrianizing city centres (both of which have been suggested by participants), would be effective in debilitating one of the main motivators for this form of transport. On the other hand, walking and cycling are discussed as pleasurable experiences, in light of the benefits to health and well-being they bring to people. Participants become very passionate when discussing aspects in relation to pleasure and well-being, as if it was more meaningful that a form of transport is pleasurable than efficient. In terms of communication then, a framework highlighting factors in relation to health and pleasure would appear to be more beneficial than those emphasizing the environmental contribution or economic advantages.

Weather and safety, however, appear to be deterrents to walking and cycling. As participants suggest, structural changes should be made to address these issues: from clearly separated bike lanes, to shower facilities or incentives in workplaces for people cycling in harsh environmental conditions. Importantly, communication should not ignore but engage with weather and safety issues, and overcoming the barriers that, as seen in the interviews, are often perceived to be more negative than they are in reality. In this regard, participants who cycle to work believe that cycling in the rain can actually be an enjoyable experience, and that cycling is not as unsafe as non-cyclists perceive it to be. Here again, hubs appear to be key in

facilitating the infrastructure needed (e.g. showers in workplaces) or encouraging positive behaviour (e.g. through incentives) to overcome the challenges related to walking or cycling in the characteristically inclement weather of GM.

When it comes to understanding the transition to a city with cleaner air, participants discussed factors that are directly and indirectly linked to air pollution, such as improved cycling infrastructure or litter-free streets respectively. This is in line with their descriptions of clean air going beyond just breathable air, to describe elements of the built environment such as greenery and spaces for people to gather. In terms of directly linked factors, participants place a greater emphasis on transport. There was a general agreement of the benefits of transitioning to electric cars as well as of reducing the number of cars on the roads. Similarly, better integrated sharing and renting schemes are seen as a viable alternative to car ownership. Participants appeared quite positive about car restrictions. In terms of active forms of transport, there was a shared opinion that both walking and cycling infrastructure have to be improved so these become safer and more pleasurable experiences. There was also a general feeling that public transport has to be improved in terms of the extent of the network, cost, ease of use, and how it is powered.

Participants also discussed the importance of greenspace in great detail. They acknowledge that creating parks is difficult and they suggest a network of greenspace composed of trees, vertical gardens, green roofs, or domestic gardens. Discussions also involved the management of green and blue areas. Participants believe that the management of these spaces needs to be improved, as many green and blue areas are perceived to be run down, attracting antisocial behaviour and becoming unsafe places.

Participants also discussed the need for more and better communication. They explained that real-time information about air pollution would be interesting, as well as communication in relation to specific behaviours and actions for citizens to adopt. In a way, participants believe in the effectiveness of information delivered through one-way communication. In their views, communication should aim at changing mind-sets and encouraging people to move away from viewing

convenience and comfort as primary factors when making transport choices. This last idea links back to active forms of transport and how pedestrians and cyclists value more highly the pleasurable experiences and the health benefits coupled to walking and cycling, than the comfort provided by the car.

Even if participants were encouraged to think freely, at times they reflected on whether what they suggested was feasible, so they did show awareness of the limitations that policymakers and planners encounter. Measures suggested by participants in relation to transport, greenspace, and clean air do not appear to be unrealistic. In fact, strategies set out for tackling air pollution in GM include action points in relation to all these areas (TfGM, 2016b, 2016a, 2018). For example, the aim of the Beelines initiative is to create an extensive joined-up cycling and walking network so these activities become easier, safer, and more attractive (TfGM, 2018). These interviews then, do not provide novel solutions that local councils are not already considering, but they do show a willingness to change and to support structural changes that are often met with scepticism, such as reducing the number of cars on the roads (e.g. de Groot & Schuitema, 2012; Gärling & Schuitema, 2007) to make space for improved walking and cycling infrastructure and green elements.

More enlightening is the discussion around indirectly linked factors. When participants imagine an urban environment with clean air, they do not just talk about environmental sustainability but social sustainability as well. They talk about placing people at the centre of development, about building cities that are human-focused. They discussed the need to create spaces where people can gather, bond, and create strong communities. Participants explained that when people are connected they care about each other, and in turn care about their physical space and the environment in which they are embedded. In their views, communities also have knock-on impacts so that positive environmental behaviours spread quicker. They refer to social sustainability and to how society should be better at tackling homelessness, at achieving a balance that it is worth maintaining in the first place.

Participants also discussed creating pleasant spaces that invite walking and spending time outdoors. In their views, clean, safe, and pleasant streets and neighbourhoods not only create opportunities for people to gather and create communities around, but invite walking and cycling as forms of transport. They explained how litter, homelessness, or antisocial behaviour, which *a priori* might not seem to be related to air pollution, deter people from commuting by foot. Similarly, safer streets and neighbourhoods – that are crime-free and road accident-free – would encourage more people to walk and cycle as their primary form of transport. This is in line with other studies concluding that the amount of greenery (such as vegetation and greenspace) or the physical management of a place (such as litter accumulation or crime) influence how people perceive air pollution (Bickerstaff and Walker, 2001, 2003; Howel et al., 2003; Bickerstaff, 2004; Saksena, 2011; Johnson, 2012; Smallbone, 2012; Xu et al., 2017).

Finally, participants discussed the importance of health and well-being in motivating environmentally friendly behaviours. According to Kollmuss & Agyeman (2002), health or well-being frames can be more powerful than comfort or efficiency in encouraging a change in behaviour in terms of transport. Participants in the present study, explained how an active lifestyle, though leisure activities in parks or commuting by foot or bike, would foster healthier citizens and communities. In their views, healthier people who also care about their well-being, are more likely to care about their environment, and to value green and blue spaces to a greater extent as places where they can enjoy fresh air as well as exercise.

Participants became more invested in the discussion as well as more emotional when talking about indirectly linked factors in relation to communities, pleasant streets and neighbourhood, health, and safety. This has important implications for communication as well as for framing and designing policies. This suggests that a greater emphasis should be placed on people, on their well-being, and the places they care about. In practical terms, road space is limited and, as can be seen in many cities worldwide, more space for pedestrians and cyclists can only be achieved if road space is reduced. The framing of this, however, could highlight having fewer cars and reducing the space designated to cars, which may be met

with public scepticism; or could instead emphasise a green city for people to walk around and gather in. In other words, these findings suggest that positive communication about health and pleasure with a human-centred focus is more likely to be effective.

These findings are specific to women as their constructions of reality are influenced by their unique experiences. Feelings of insecurity are particularly specific to women. Statistics show that women cycle less (UK Census 2011) and, as one of the participants pointed out in the interview, they also cycle differently, failing to claim their space on the road. Similarly, as the literature and participants suggest, women often feel insecure when walking home at night on their own (Root et al., 2000; Roberts, 2016a). These embodied experiences will therefore shape their mobility and understanding of the city. Cost in relation to transport will also be experienced differently by women. As stated earlier, statistically women suffer from economic inequality and lower salaries (Chalifour, 2011; Buckingham, 2016), and in turn their transport choices and their perceptions of cost are shaped by this reality (Johnsson-Latham, 2007; Polk, 2009). Women's experiences of comfort and efficiency will also be influenced because they take on greater responsibility for unpaid work: they often conduct chained trips, carry heavy grocery bags, and travel with children or elderly people requiring prams or wheelchairs (Bauer, 2009; Madariaga, 2016b; Beebeejaun, 2017). As participants pointed out, the car is a simpler option when having to carry heavy bags home or when having to "ferry" children around to extracurricular activities. In the interviews, participants explained how weather affects their travel choices when children are involved. It follows then, that because women are in charge of escorting children to a greater extent, weather can have a greater impact on the travel choices of women than those of men. Statistically women travel fewer kilometres than men in an average week and are often more tied to their local environment (Johnsson-Latham, 2007; Polk, 2009; Pearse, 2017). Studies show how women walk more and rely on public transport to a greater extent (Polk, 2009). These factors increase the time women spend outdoors, and will consequently impact on their experiences of the urban environment, litter, homelessness, greenspace, and air pollution (Garcia-Ramon et al., 2004; Buckingham, 2016).

The fact that these findings are specific to women, however, does not make them less valid in relation to men or society at large. The reasons why the voices of women are key in shaping future cities for all are threefold. Firstly, because they already lead more environmentally friendly lifestyles, covering fewer kilometres and, when travelling, walking and using public transport to a greater extent. Secondly, because their needs arise from a response to societies with longer life expectancy and a mobility of care that must be catered for. And thirdly, because they are tied to economic inequality and physical vulnerability which, although a major disadvantage in the case of women, is not limited to them, and is also experienced by different demographics, such as students or LGBT communities respectively. In other words, integrating the voices of women will help to make more environmentally friendly cities where equality and safety are at the centre; cities that are equally attractive for women as they are for the rest of society. There are various examples in the literature of how women-centred urban development approaches have brought benefits for societies at large in different European countries, such as Austria, Spain, or the Netherlands. Some of these benefits 'for all' that arise from incorporating the perspectives of women in architecture, urban planning, or transport design include: an improved work-life-balance, improved ageing strategies, shorter commutes, improved transportation systems that allow commuting without a car, improved liveability, quality of green and open spaces, safer streets and neighbourhoods, and spaces for events and community life that bring about social sustainability (Damyanovic, 2016; Irschik et al., 2016; Ruiz-Sanchez, 2016; Ullmann, 2016; Wankiewicz, 2016; Wotha, 2016; Alber, 2018).

Although this study tried to give voice to women with different backgrounds (e.g. age, ethnicity, or professional background) and experiences (e.g. number of children or preferred form of transport), it does not encompass the voices of *all* women. Although the professional background of participants is diverse – e.g. school teachers, researchers, policymakers, architects, students, and homemakers – they hold a position of relative economic privilege. It is important to acknowledge that these findings do not encompass the voices of other less privileged women and that this is a limitation of the study. This links to the idea

that it is the socially advantaged actors who most often end up participating in deliberative processes as they feel more encouraged to partake (Young, 2001).

Although this study subscribes to the need for an all-encompassing gender perspective, it also acknowledges the importance of intersectionality (Chapter II, section 2.3.3). That is, a gender perspective is necessary for the time being, even if it can be incomplete in understanding the nuances of different backgrounds and positions in society. This is because today a gender perspective is still often absent, and at times undervalued or misunderstood (Madariaga, 2016a). In the future, however, greater attention should be paid to the experiences of women that intersect with social identities such as race, income, education, age, marital status or job situation, and that give rise to differences in how the environment is perceived and sustainable lifestyles conceptualised (Kaijser and Kronsell, 2014).

5.5 Summary

The voices of women have been invisible when it comes to debates and policies concerning air pollution as well as sustainable transport. These voices however are key in shaping cities and forms of transport that are environmentally friendly, as well as safe, cost-effective, and which facilitate juggling paid and unpaid work. In this context, women were interviewed to explore their experiences of air pollution and ideals of a future city with clean air. This study finds that when women's voices are made visible, air pollution is not as invisible as it has been portrayed in the literature and that physical accounts of air pollution emerge. Clean air is understood in terms of the air being breathable and alive, but participants give more attention to the physical aspect of the urban environment, such as being green and calm, than the air itself. Feelings in relation to air pollution are negative, involving anger, sadness, concern and helplessness, which results in pessimistic visions of a city with clean air. Active forms of transport, that are so key in tackling air pollution, are discussed in terms of health, well-being, and pleasure and these appear to be more powerful and significant than other motivations, such as the comfort that is associated with private car use. Weather and safety – from being

attacked or run over – are two important barriers associated with active forms of transport. Finally, factors that are not directly linked to air pollution, such as pleasant and safe spaces free of litter and crime, healthy people, and strong communities, are as important as transport improvements that are directly linked to air pollution.

The analysis of these interviews has found six implications for communication.

(1) First, that air pollution should be communicated as something physical, moving away from the invisible and ungraspable adjectives that encourage people to avoid the problem altogether.
(2) Second, that communication emphasises aspects of the urban environment that are easier to perceive and relate to than discussing the air itself, such as calm and pleasant environments where people can walk freely without being in a constant state of alertness for cars.
(3) Third, that there is a need for positive communication able to motivate people to change, rather than paralysing or scaring them which translates to pessimistic feelings about the future.
(4) Fourth, that the health and well-being frame should be explored further, as it is placed at the centre of the discourses of the people who already prefer active forms of transport for their daily commutes, and can in turn be effective in motivating change in society at large.
(5) Fifth, that the two barriers in relation to active forms of transport (i.e. weather and safety) are addressed through communication, structural changes, and incentives, and that hubs play a key role in such task.
(6) And sixth, that structural changes are needed in relation to indirectly linked factors (such as cleaner streets and neighbourhoods), and that direct factors that can be met with public scepticism (such as closing roads to traffic) are framed in light of the indirectly linked factors. That is, that this highlights pleasant and calm spaces for people to walk, gather, and enjoy the city, that go hand-in-hand with reduced road space for cars.

Chapter VI

Conclusions

This thesis was written as a response to a lack of sufficiently radical public action in relation to the air pollution crisis affecting cities worldwide. This work originated from the struggles to encourage the rapid lifestyle changes needed in culturally and socially diverse societies, where the environment is conceptualized in a myriad of ways. It was inspired by the slowly growing body of work concurring on the importance of an in-depth exploration of gender in relation to sustainable mobility, and of promoting the voices of women in designing inclusive and safe transport systems and cities.

The aim of this thesis has been to investigate how public engagement with air pollution can be made more effective. Not only so that policies are met with public acceptability, but also so that communication is able to encourage behavioural changes when it comes to transport choices. This thesis has investigated the benefits of two-way communication processes, as well as how these can be established between experts and members of the public. It has explored public perception of air pollution and information consumption habits of citizens in Greater Manchester (GM), and examined what factors shape these. It has also studied how women in this conurbation both experience air pollution and imagine a city with cleaner air. Ultimately, the aim of this thesis has been to advance knowledge in the field of public engagement with air pollution, and to provide recommendations (Section 6.1 and Section 6.2) for policymakers.

Chapter III described results from a systematic review of 50 studies exploring how two-way communication can be established between experts and the public. This was based on the premise that a one-way provision of information does not realise the full potential of public engagement as it fails to consider crucial aspects, such as the previous experiences and needs of the public, and an individual's pre-existing knowledge and understanding, or trust in a source. This systematic review concluded that there is no one-size-fits-all format of communication, and that the suitability of each medium is tied to its communication purpose. For example, incident-oriented communication (e.g. an air pollution crisis) needs the immediacy and remoteness of social media; whereas knowledge exchange between experts and the public (e.g. in designing structural changes that are relevant and effective in tackling air pollution) is better suited to a face-to-face encounter that allows for

discussion and negotiation. The suitability of each medium is also tied to the people involved. Social media could impede older generations from participating, while forums, where the public and experts meet face-to-face, are often exclusive to members of the community who feel confident and empowered to participate. In this regard, opinion leaders or intermediaries become key players. These can be people who are trusted (e.g. nurses), people who already have access to certain communities (e.g. school teachers), or empowered members of these communities (e.g. those with a higher level of education). Audience segmentation strategies are necessary, and due to the unsuitability of one single format in reaching the many publics that coexist in a community, different communication formats should be employed to target multiple publics. Furthermore, this analysis supports the idea that information alone is not sufficient and that strategies are needed so that engagement becomes more meaningful (e.g. hands-on activities).

Chapter IV described the results of a questionnaire with both male and female residents in GM and explored public perception of environmental hazards and information consumption habits, as well as factors that influence these. This part of the study concluded that 57% of respondents were aware of pollution, but that they failed to fully grasp the health consequences that are caused by it. Participants believed that pollution is mainly a human-made problem, and acknowledged their responsibility to act. Scientists were perceived to be highly trusted when it comes to issuing information, unlike the media and the government. Despite this, TV, social media, and newspapers were more widely employed for accessing environmental information than other more expert sources, such as specialist publications or special events (e.g. science festivals). Communication, then, appeared to be taking place through un-trusted one-way communication processes – rather than through more effective dialogical approaches with more trusted sources. Education level was key in shaping perception in relation to pollution, trust, and information consumption habits. Age and postcode appeared to exert influence to a lesser extent, and at times their influence was intertwined with that of the level of formal education. Gender was also key in shaping perception of both threat in general terms, as well as pollution, and this variable was independent of educational level. Despite this, and the fact

that a slowly growing body of work suggest it is key in understanding sustainable mobility, gender is the least explored factor in the literature.

Motivated by the findings in Chapter IV, Chapter V described the results of a series of qualitative interviews with women in GM. This part of the study concluded that transport was at the epicentre of these interviews, as participants perceived it as the main source of air pollution as well as their major individual contribution. Women in this study discussed having physical experiences of air pollution. They explained that it can be seen, felt, smelled and tasted. Feelings in relation to air pollution were negative, involving anger, sadness, concern, and helplessness, which resulted in pessimistic visions of a city with clean air and of the effectiveness of taking action. If health and well-being were at the heart of the discourses of women, and appeared to be strong motivators for active forms of transport, then weather and safety (e.g. from being attacked or run over when riding a bicycle) were two important barriers. Participants believed that factors such as crime, litter, or homelessness were indirectly linked to air pollution, as negatively influencing their experience of the outdoors, and that they were an impediment to walking.

6.1 Recommendations for public engagement

Based on the findings of this thesis, a series of recommendations for effective communication and engagement in relation to air pollution are presented. These recommendations can be equally helpful for policymakers or charity organizations.

- There is neither a **one-size-fits-all nor a superior format of communication**. No single format analysed in this study (i.e. social media, educational programmes, serious games, citizen science, and forums) is effective in fulfilling different communication purposes (i.e. dealing with an emergency, raising awareness, or facilitating knowledge exchange). For example, the immediacy and remoteness of social media would enable an air pollution crisis to be dealt with effectively. The opportunity for a face-

to-face negotiation provided by forums, on the other hand, would perhaps be more satisfactory in the long-term improvement of the emergency response to such crisis through an expert and experiential knowledge exchange process. Forums could also be employed for policymakers and the public to jointly design structural changes that are relevant in a particular neighbourhood or community (e.g. cycling lane). This recommendation is based on Chapter III.

- **Audience segmentation** is essential when it comes to **information sources**. In this study, more educated people trust scientists to a greater extent and younger generations don't perceive the government to be as untrustworthy as older generations do. For example, although communication with government officials or policymakers might not be effective with older generations, it shouldn't in principle be compromised when dealing with younger people. Furthermore, trust in government can be further compromised in the case of affected communities, if this fails to provide a solution or alleviate their situation (e.g. parents of school children where air pollution is high). In this case, other sources that are not involved in policymaking or planning might be a more trusted or respected option. This recommendation is based on Chapter III and Chapter IV.

- **Audience segmentation** is also essential when it comes to communication **format or media**. In this study, age, postcode area, educational background, and gender were all found to influence which communication formats are preferred. Younger people were found to prefer social media while older generations prefer accessing environmental information through newspapers. More formally educated people rely on specialist publications to a greater extent; and women report using special events (e.g. science festivals or informal talks) more. For example, a possible interpretation of why people in postcode area M relied on scientists for information to a greater extent than in other places, was that there are a larger number of special events and science festivals taking place in that area, and that three major UK universities which often hold events (e.g. book launches, public lectures) are based there. Considering that, as found

here, scientists are highly trusted, an engagement solution would involve developing these types of activities in areas that have until now been underserved. This recommendation is based on Chapter III and Chapter IV.

- **Audience segmentation** is furthermore essential when it comes to **the message**. In this study, both educational level and gender affect how threat and air pollution are perceived, and this should be addressed accordingly through communication. For example, as women are aware of air pollution to a greater extent, it is recommended that communication addresses this issue learning from their lived experiences. That is, communication to this public should highlight how air pollution can be physically experienced, referring to how it can be smelled or tasted. This recommendation is based on Chapter III, Chapter IV and Chapter V.

- **Opinion leaders** can be key in overcoming trust issues and in targeting communities that are not already engaged. Opinion leaders can be useful as they are already trusted in their communities (e.g. Chris Boardman), and because they have access to communities of interest (e.g. nurses). For example, school teachers could be key in shaping transport choices of students and their families. The role of opinion leaders is also related to the power of hubs (i.e. networks of people, such as schools, universities, or workplaces) in encouraging positive behaviour, such as Walk or Cycle to Work schemes in workplaces. This recommendation is based on Chapter III, Chapter IV, and Chapter V.

- **Effective engagement should be made meaningful.** Information alone is not sufficient and hands-on activities allow experiential learning. Examples of this could be serious games where simulations allow learning how air pollution levels are affected by increasing the amount of vegetation and reducing the number of cars on the roads; or taking air pollution measurements (e.g. as part of a citizen science initiative) to truly grasp the severity of the problem and how it changes across the city or times of day. This recommendation is based on Chapter III and Chapter V.

- **Call-to-action messages** are key in motivating behavioural change. Different studies conclude that citizens believe their actions have no impact and that the responsibility to act does not belong to them. In this study however, citizens in GM reported feeling responsible and acknowledged the impact of human activity on air pollution. In this context, communication should clearly articulate what individuals could and should be doing. Initiatives in this regard would include events such as cycle-to-work-days, commuting events that encourage citizens to try out this form of transport and raise the visibility of cyclists. This recommendation is based on Chapter IV and Chapter V.

- **Two-way communication formats** that encourage dialogues between experts and the public, or between various members of the public can, in principle, be more effective and should be employed to a greater extent. Although citizen science or games appear to be effective in creating the binomial fun-knowledge combinations that are so important for learning, these are rarely used in GM. TV, social media, and newspapers are employed widely even when they are not as effective in making engagement meaningful, facilitating hands-on experiences, or even when the media is not trusted to a great extent. The argument is not that these should be avoided entirely, as participants believe can be effective and already widely employed by citizens, but that they are complemented with other types of engagement (e.g. dialogical or that allow experiential learning). This recommendation is based on Chapter III and Chapter IV.

- There is a need for **positive communication** that is able to motivate people to change, rather than paralysing or scaring them which translates to pessimistic feelings about the future. Many of the feelings reported about air pollution are about sadness, anger, and helplessness. It is recommended that air pollution would be better communicated along the lines of an exciting transformation and future. This recommendation is based on Chapter IV and Chapter V.

- Communication should highlight the **individualized consequences of air pollution** on people's health. In this study, although there was a general awareness of the air pollution problem, participants failed to grasp its health consequences at an individual level. It is commonplace in the literature that the health consequences of air pollution are perceived at a societal level but not an individual one. Communication, then, should address the fact that air pollution is directly affecting people – in and around GM – and their health. This recommendation is based on Chapter IV.

- Air pollution would be better communicated by **framing it as something physical**, moving away from the invisible and ungraspable adjectives that encourage people to avoid the problem altogether. If it can be touched, smelled, felt, and tasted, then it is recommended that communication is established on these grounds. This recommendation is based on Chapter V.

- Communication of air pollution should be **framed in relation to the aspects of the urban environment** that are easier to perceive and relate to than discussing the air itself, such as calm and pleasant environments where people can walk freely without being in a constant state of alertness for fear of cars. This recommendation is based on Chapter IV and Chapter V.

- Communication should explore the **health and well-being frame** further, as it is central to the discourses of the people who already prefer active forms of transport for their daily commutes, and who can in turn be effective in motivating change in society at large. Participants become very passionate about walking and cycling as such activities keep them fit, active, happy, and healthy. These feelings and experiences appear to be much more dominating than other advantages, such as the comfort factor that is usually associated with the car. This recommendation is based on Chapter V.

- Communication should explicitly **address weather and safety issues**, as these are the two barriers linked to active forms of transport. Structural changes, incentives, and hubs can play a key role in such task. This recommendation is based on Chapter V.

- Communication should address **factors that are indirectly linked to air pollution**, such as pleasant neighbourhoods and cleaner streets, when dealing with structural changes or policies that can be met with public scepticism. That is, communication should highlight pleasant and calm spaces for people to walk, gather, and enjoy the city, and which come hand-in-hand with reduced road space for cars. This recommendation is based on Chapter V.

Based on the findings of this thesis, a recommendation is presented for how structural changes and policies can be more effectively designed in tackling air pollution:

- **Structural changes** in relation to directly linked factors (e.g. improved cycling infrastructure or car free zones) should come hand-in-hand with structural changes **in relation to indirectly linked factors** (e.g. cleaner and safer streets). These findings suggest that clean, safe, and pleasant streets and neighbourhoods invite walking and cycling as forms of transport. Litter, homelessness, or antisocial behaviour, which *a priori* might not seem to be related to air pollution, deter people from commuting by foot. They also deter people from spending time outdoors more generally. Time spent outdoors is translated into a greater awareness of air pollution and caring about the environment; as well as in creating community bonds that make people care for each other's health and well-being. Similarly, safer streets and neighbourhoods – that are crime-free and road accident-free – would encourage more people to walk and cycle as their primary form of transport.

Although some of these recommendations originate specifically from interviewing women, they are not only effective in engaging this collective and can be applied

when communicating with other groups in society. For example, highlighting the safety aspects of a city can also be effective with other communities that experience fear to a greater extent (i.e. BME or LGBT communities). Many of these recommendations arise from experiences of a collective already leading more sustainable lifestyles (e.g. who are more likely to commute by foot) and can therefore be key in motivating laggards – a term employed by (Rogers, 2003) to refer to the last group of people in society to adopt an innovation.

Although these guidelines arise from an in-depth exploration of one particular geographical region (i.e. GM), they are still applicable to a wider context. That is, it might be that it is only older generations in GM that employ specialist publications for accessing information about air pollution. But what *is* transferable is the recommendation to consider audience segmentation in relation to the format, media, and message.

Ultimately, it is important to close by highlighting that these recommendations for communication and policymaking arise from a social study dealing with public perception. They arise from a study that pays special attention to different groups in society, specifically women. These recommendations arise from an exploration of all the factors that have been discussed to influence perception and information processing: prior knowledge and understanding, trust, needs, concerns, as well as previous experiences.

6.3 Further research

This thesis has raised a number of avenues for further research. First, in the future studies should focus on specific two-way communication formats in action and explore what the benefits and limitations of these are when employed to engage the public with air pollution. For example, what are the outcomes and audiences of forums in relation to designing policy-solutions for air pollution?

Second, in the future, studies should address why the media is the most widely used source when accessing information about the environment, even if it is not highly trusted in comparison with scientists. For example, what are the uses and gratifications of using the media, on the one hand, and specialist publications, on the other, for accessing environmental information?

Third, future research should focus on a better understanding of what determines relative priorities. In order to understand how concerning air pollution is for citizens in GM), studies should concentrate on analysing how relative priorities change in relation to important events. In 2017, during the very early stages of survey data collection, Manchester suffered a terrorist attack where 23 people were killed and more than one hundred injured (Dodd et al., 2017), although this is an unexpected event and impossible to plan for, flexibility in the research design could allow for its incorporation into the study. A better contemporary example might be Brexit (i.e. the withdrawal of the United Kingdom from the European Union). For example, does public concern of air pollution change in the context of political instability produced by such an event?

Fourth, future studies should address differences in perception through qualitative studies. A questionnaire study is effective in gaining a quick overview of public perception of air pollution and identifying factors that shape it. In the future, a more in-depth exploration would enable better understanding of why the differences arise. For example, how do people in different postcode areas discuss their relationship and access to scientists and expert sources of information?

Fifth, the literature on how women envision a sustainable future is scarce, and future research should replicate this study in other geographical contexts. For example, are indirectly linked factors identified by women (e.g. homelessness) subject to place?

Perhaps the main avenue for further research involves paying attention to the intersections, where gender meets race, educational level, or class. For example,

how is the future of sustainable transport imagined at the intersection of gender and race?

This thesis has explored the possibilities of two-way communication in relation to air pollution. It has investigated how different demographics in GM perceive air pollution and access related information. It has also identified that gender is a central factor when it comes to air pollution, and it has consequently explored the voices of women in relation to clean air. In doing so this thesis has demonstrated the importance of establishing dialogues about the future of air pollution with groups in society that have been traditionally underserved. It is also hoped that the research reported and discussed in this thesis will have: extended the literature on public perception of air pollution; provided a series of useful recommendations for policymakers and charity organisations for how to engage the public and design structural changes more effectively; and to have inspired other researchers to explore one or more of the avenues for further research suggested above.

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Appendices

Appendix 2.1

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Give me five! – reasons for two-way communication between experts and citizens in relation to air pollution risk

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Abstract. Air pollution is a major environmental concern for many populations worldwide. Communication efforts so far have been based on a one-way provision of evidence and information from experts to society, and have arguably failed in their mission to foster a more aware and engaged society, or to result in cleaner air. Globally we are facing both an air quality crisis and a communication emergency. This paper focuses on the communication of air pollution risk, from the threats it poses (e.g. severe impacts to human health) to the opportunities it can create (e.g. behavioural or technological alternatives that lead to cleaner air). It supports the case for moving away from one-way communication, and identifies five key benefits of a practical two-way communication between experts and citizens in order to engender positive change and improve global air quality.

1 Introduction

According to the World Health Organization (WHO), 92 % of the world's population live in places that exceed the recommended annual mean concentrations of $PM_{2.5}$ (10 µg m^3 as established by WHO; WHO, 2016). This exposure has been linked to cancer, asthma, stroke and heart disease, diabetes, obesity, and dementia, and it is causing about 3 million deaths per year globally (WHO, 2016). Air pollution, however, is a constant and silent threat, that is not easily grasped without the help of visual or olfactory cues, such as smoke emanating from factories, car congestion in main roads within an urban centre, or an uncomfortable odour when standing next to a running car (Bickerstaff and Walker, 2001). This strong human component, where the citizen is "both a source and a victim" (Xu et al., 2017, p. 2), turns air pollution into a social issue, not just a scientific one. On the one hand, citizens need to understand the effects of air pollution on human health, as well as when and how to follow protective behaviours. On the other hand, citizens need to be aware of their contribution to air pollution and the mitigating behaviours already available to them, so that they can participate in the co-design of new alternatives that lead towards cleaner air. The severity of the threat that air pollution is posing worldwide, together with inaction and lack of engagement, can be described as a "communication emergency" (Priest, 2016). It appears then, that communication is key in bringing society up to speed with the problem that air pollution is posing worldwide. This paper is concerned with communication of the threats and opportunities of air pollution risk (conforming with the definition of risk stablished by ISO 31000:2018, a set of principles and guidelines for risk management codified by the International Organization for Standardization); it reflects on the need to move away from one-way provision of information from experts to society and towards two-way dialogue, and stablishes five benefits to be gained from this dialogical approach, identifying it as a vehicle for communicating awareness and facilitating change.

2 The case for moving away from a one-way provision of information

Communication in relation to air pollution has, until now, mainly been following the "deficit" model (Bickerstaff, 2004). This model adopts a "one-way, top-down communication process", through which scientists fill "the knowledge

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vacuum in the scientifically illiterate general public" with the information they believe to be relevant (Miller, 2001, p. 116). A one-way approach to communication, however, is unlikely to bring about the change needed to tackle air pollution, because it fails to consider a series of factors that are key determinants of the way people perceive and react to information.

The amount of information required to relate to a topic in a meaningful way varies from one individual to another. People rarely seek "*all* the science available"; rather, they want "enough" as to be able to "make up their minds about an issue" (Priest, 2016, p. 5). Sufficient information for one individual will not be enough for another, and information that exceeds or does not reach this threshold is unlikely to be effective. In other words, there is not a one-size-fits-all package of information able to engage society as a whole in regards to cleaner air. In addition to the amount of information individuals need, the way this information is presented will also have an impact on how it is perceived and taken on board. The complexity of the topic, the technicality of the information, and the framing of the message have all been proven to influence the successfulness of communication, and these too are subject to individual differences (Bickerstaff, 2004; Burningham et al., 2008; Cacciatore et al., 2016).

Indeed, even if a message sent through one-way communication had "enough" amount of information, the appropriate amount of complexity and jargon, and was framed in a suitable way, it would still ignore "the significant role of the environment and the individual as critical determinants of that information's use" (Longnecker, 2016, p. 4). Individuals are not passive receivers of information, ready to absorb and act upon the information received; they have beliefs, values, needs, and previous experiences that will influence, not only the way the information is processed, but also the consequent action (or inaction) it triggers (Harre, 2011; Longnecker, 2016). Together with the individual, the environment in which individuals are embedded is also a critical determinant of how information is acted upon (Longnecker, 2016). The norms that govern communities, as well as what oth- ers think, have proven to influence an individual's behaviour (Cacciatore et al., 2016; Longnecker, 2016; Priest, 2016), and information that does not fit or goes against these external factors is consequently likely to be discarded.

The source of the information is another factor that influences how it is perceived and assessed (Rogers, 2003). "It is not just the message but the messenger, then, that matters" (Priest, 2016, p. 56), and lack of trust in a source, such as the government, the media, or scientists, has proven to affect responsiveness to the message (Bickerstaff, 2004; Bultitude, 2011; Goodwin and Dahlstrom, 2014). Mere provision of evidence and information by a source perceived to be untrustworthy is unlikely to be effective. For instance, a lack of trust in the government can affect how people perceive policies in relation to climate change (Priest, 2016), or air pollution.

Finally, people reject information that goes against deeply held beliefs or that completely challenges their own lifestyles – a tendency known as "cognitive dissonance" (Festinger, 1962; Lorenzoni et al., 2007; Priest, 2016). The fact that one's lifestyle is actually a root cause of air pollution, and consequently one has to modify established behaviours, is not easily accepted. Although individuals might not necessarily deny their contribution to air pollution, they are likely to take refuge in day-to-day obligations and priorities. Merely providing evidence is, therefore, unlikely to overcome this issue (Priest, 2016).

2 The case for two-way communication

Two-way communication involves two or more "communicators" who both send and receive information (Bowater and Yeoman, 2012), moving away from the linear model of communication comprising the figures of a "sender" and a "receiver" (Shannon and Weaver, 1998). In contrast to the "deficit" model, the "dialogue" model highlights that "while scientists may have scientific facts at their disposal, the members of the public concerned have local knowledge and an understanding of, and personal interest in, the problems to be solved" (Miller, 2001, p. 117). It highlights the need to explore the identities and social norms of different groups in society, as well as the importance of acknowledging the existence of "many publics", in contrast to what the old model referred to as "the public"(Priest, 2016). Here we present five key benefits of two-way communication between the public and experts in relation to air pollution risk. These benefits will increase the likelihood of engendering positive change – whether this is tied to mitigation and adaptation behaviours in the polluter, or protective behaviours in those suffering from pollution – and improving global air quality.

Firstly, two-way communication can improve technology and policy development in relation to air pollution. Tackling the issue of air pollution involves the development of new technology (such as hydrogen fuel cells or electric cars) for which societal acceptance is needed at the development and regulatory phases (Wilsdon and Willis, 2004). Similarly, new policy solutions are needed that can drive societies towards cleaner air, for which citizen involvement would be translated into better and more robust policy and funding decisions. The "Australian Climate Policy Forum", for example, composed of experts and twenty four citizens holding different views about carbon pricing, was created to evaluate the current governments' efforts and future directions of the emissions mitigation strategy, where citizens were invited to "jointly articulate criteria for a preferred carbon pricing policy" (Lo et al., 2013, p. 7). Although at the start of the forum there was a lack of consensus, the group agreed to support the notion of a carbon tax, as long as the implementation would rest on trusted and transparent administrative mechanisms. The key for finding consensus was to overcome trust

issues in relation to the collection and management of the funds collected in the case of the implementation of a carbon tax (Lo et al., 2013). In a different forum in Kenya, the discussion evolved around measurements to reduce air pollution at the individual and community level. As a result, the group proposed a series of well-defined actions that the government could take, such as removing old vehicles that were not properly maintained from the roads, due to their significant contribution to the air pollution problem (Ngo et al., 2017).

Secondly, beyond exploring individuals' needs and aspirations in relation to policy and scientific or technological developments, two-way communication can easily gather additional data on air pollution. Citizen science initiatives, which are gaining prominence at an increasing rate, are designed to actively involve citizens in "collecting, generating, and analysing data" (Illingworth and Allen, 2016, 5–12). These encounters allow citizens to gather knowledge or data that would be impossible to collect on their own in terms of quantity and accessibility. A citizen science project measuring exposure to the Deepwater oil spill had citizens contributing with information of what they saw and smelt. This project explains how an aggregation of citizens can detect "a broader range of impacts", such as "smells, smoke, and other potential risk factors", and these data may then be employed to "shape the conduct of political decision-making and/or the development of expert science" (McCormick, 2012). Another relevant example is the Air Quality Egg project, in which citizens – using an egg-shaped device – measure air pollution levels in their surroundings, upload them to the internet, and compare pollution levels recorded by other eggs elsewhere. The Air Quality Egg project is a community- led initiative that facilitates participation in the conversation about air quality (Muller et al., 2015).

Thirdly, this dialogical approach found in citizen science initiatives, and in citizen participation in a broader sense, raises the levels of awareness of, and engagement in, air pollution reduction of the people involved. For instance, a project involving citizens in air monitoring campaigns in four European cities (Antwerp, Kassel, London, and Turin), concludes that "the most effective way of producing a change is involving the citizens themselves in monitoring campaigns" (Sîrbu et al., 2015). A different example in Kenya, involving women in air pollution measurements and further discussion with experts, also concludes that "participation in conducting and interpreting air quality studies helped residents improve their understanding of air pollution and also helped them develop responses to it" (Ngo et al., 2017, p. 177). A reduction in the discrepancy between real and perceive levels of air pollution after participating in monitoring campaigns, as well as a more accurate identification of air pollution sources are some examples of the ways in which active participation is able to change levels of awareness (e.g. Ngo et al., 2017; Sîrbu et al., 2015). Examples of behavioural change as a result of active participation are different actions in which residents get involved to reduce the impacts that air pollution causes to them and their communities, such as planting trees, avoiding pollution areas or sources, or switching to clean cook stoves (e.g. Ngo et al., 2017). The positive outcomes of citizen science, and citizen participation more broadly, have been attributed to the capacity to promote place-based learning. This means that individuals are able to relate scientific information to their communities, making it more comprehensible and relevant (Groulx et al., 2017). Additionally, participants develop stronger ties to their surrounding environment, which is in turn translated into a more intense feeling of caring about an issue, such as clean air for their community. Furthermore, participants also create social bonds with experts, and other people in their community, which then results in more regular participation and more meaningful involvement with an issue (Groulx et al., 2017).

Fourthly, two-way communication can help provide a better emergency response to an air pollution crisis. In such a crisis, like the Southeast Asian Haze in 2013, both experts and affected populations have valuable information that can help provide a more accurate response. If the experts can send out warnings and information on how to behave that are valuable to the public and will improve their course of action (e.g. staying indoors or limiting outdoor physical activity), citizens can contribute with on-the-ground experiences or information about their physical and psychological well-being. As explained in the Southeast Asian Haze example, this "is important in assessing how the population is coping and responding thus far to the crisis" and in providing better support tailored to that information (Zhang et al., 2014).

Fifthly, two-way communication can improve trust between citizens and professionals working with air pollution. On some occasions, when experts and the public work side-by-side, either in citizen science projects or in deliberative encounters, they inevitably increase their levels of trust in one another, which in turn encourages further dialogue and more effective communication in general. As trust, after all, is about being able to relate to the other person (Corner et al., 2018). A community forum organized in Kenya to discuss air quality and its health impacts, concluded that "involving local people and discussing the scientific data, as opposed to simply reporting measurements done by academics alone, helped generate trust" (Ngo et al., 2017, p. 181). In other words, if it is commonplace that citizens tend to question the interests of governments in relation to air pollution and environmental management, the climate of distrust is more prominent in those segments of the population that are more economically and socially disadvantaged and that are more disconnected from the decision-making process. This reinforces the fact that proximity and dialogue between these two groups can be understood as trust restorative tools (Bickerstaff, 2004; Walker et al., 1998).

Two-way communication in relation to air pollution risk can take many shapes as it is being carried out through multiple innovative formats. Social media, for instance, can be

used in relation to an incident, such as the aforementioned air pollution crisis (e.g. Zhang et al., 2014), as well as to raise awareness and discuss what measures individuals can implement in their day-to-day activities (e.g. Kay et al., 2015). The effectiveness of social media relies, on the one hand, on that it allows dealing with the immediacy coupled to a crisis event; and on the other hand, on the horizontal lines of interaction between members of the public encouraging different voices to be heard. Educational programmes and serious games, for example, can also be employed to raise awareness of how our actions are contributing to air pollution and what adaptation and mitigation behaviours are already available, as well as to foster more technical knowledge, such as deeper understanding of city development problems leading to pollution. The effectiveness of these two formats relies on the binomial fun and knowledge combination, which is often achieved by incorporating gamification elements, rich visualizations, or hands-on activities. Citizen science initiatives too can contribute to increasing levels of awareness. The effectiveness of this format relies on active learning and on having hands-on activities, such as the aforementioned case in which participants were involved in taking measurements of personal exposures to air pollution. In turn, the large amount of data recorded by multiple individuals in citizens science initiatives, contributes to advancing knowledge as this data could otherwise not be collected by experts alone (e.g. Sîrbu et al., 2015). Discussion forums – in which experts and citizens meet face-to-face and spend extended periods of time discussing an issue in-depth – can be employed for them to work together towards the formation of policies, as well as to develop scientific and technological expert knowledge that, by exploring and integrating local and experiential knowledge, becomes more relevant at the local scale (e.g. Whatmore and Landström, 2011). Finally, poetry can be employed to foster positive change at the community level, to facilitate discussion between experts and the public, and most importantly, to invite communities that often find themselves neglected to participate in dialogues and debates about issues such as air pollution (Illingworth and Jack, 2018). The intrinsic characteristics of these formats show that the different benefits or outcomes obtained from two-way communication appear to be tied to specific communication formats.

Two-way communication varies in the degree of engagement and bidirectionality it allows, as well as in how much control are experts willing to cede. The varying degrees of engagement have been explained with the metaphor of a ladder (Arnstein, 1969) from lower rungs aiming at mining citizens' knowledge, to higher rungs granting citizen control. Engagement will not always be an equal partnership in which the public is involved from the early stages, is encouraged to deliberate jointly with the experts, in which both agendas are pushed equally, and there is the goal of reaching consen- sus. This would be the ultimate form of engagement aiming to "improve the quality of decision-making, to create more socially robust scientific and technological solutions" (Wilsdon and Willis, 2004, p. 39). Sometimes these dialogues may only seek citizens' opinions and explore different views of, for instance, a new technology or a new policy. Although this latter form of dialogue – which has been subject to criticism – is less than optimal as it can be seen as an appeasement (Arnstein, 1969), or as an instrument of governments and companies to be able to "sell" their developments and policies better (Wilsdon and Willis, 2004), it can also be seen as a step closer to citizen participation in which individuals and their environments are explored and taken into consideration.

2 Conclusion

In order to maximize the chances of communication of hazards in general and of air pollution in particular being effective in fostering more aware and engaged citizens, communication must go beyond a one-way provision of information. Effective communication requires consideration of the amount of information that is necessary, as well as the language and framing of the message itself, all of which are subject to individual differences. It has to explore the inner world of the individual, as well as the environment in which it is embedded. Additionally, communication needs to overcome trust issues. A dialogical approach offers the opportunity and mechanism to do this, and it is therefore much more likely to be both effective and efficient.

We suggest here that air pollution experts should consider two-way forms of communication and explore the benefits that a dialogical approach can offer. For a scientist, a policymaker, or a member of the emergency services, engaging with citizens can translate into more relevant and robust outcomes, whether these are scientific advancements, technologies, policies, or crisis responses.

Two-way communication in relation to air pollution has (at least) five benefits: (i) it can facilitate the formation of policies, as well as scientific and technological developments that are more relevant for society; (ii) it can help complement data gathered by experts; (iii) it can improve societal awareness and encourage necessary protective and mitigation behaviour; (iv) it can offer a more accurate response to a crisis; and finally, (v) it can improve levels of trust between public and experts. All of these benefits are essential if the air pollution challenge faced locally and globally today are to be successfully tackled.

Despite the clear benefits, effective two-way communication is a challenge and there are still important questions to be addressed. Further research should have a greater focus on *processes* – rather than outcomes. That is, on understanding how positive experiences can be granted for everybody involved so that participation and dialogue are seen as something enjoyable and worth devoting time to. In relation to this, further research should also investigate how experts as well as members of the public can engage in these time-consuming initiatives when they are already faced with too

many demands on their time. Finally, further research should also explore if, and how, these encounters are developed differently when they are initiated by experts or by members of the public, and how their status, priorities, knowledge, etc. impose on the dynamics and dialogues these encounters elicit.

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Appendix 3.1

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Research article

Building bridges between experts and the public: a comparison of two-way communication formats for flooding and air pollution risk

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Abstract. Urban centres worldwide are adversely affected by flooding and air pollution. Better-prepared citizens are crucial to limiting the impacts of these hazards, and both lay knowledge and personal experiences are important in complementing and challenging expert opinion. For the first time, this study offers a critical comparison of how different two-way communication formats have been used worldwide between experts and the public in relation to flooding and air pollution risk. Through a systematic review, we analyse social media, educational programmes, serious games, citizen science, and forums in terms of their effectiveness in respect of dealing with incidents, raising awareness, and promoting knowledge exchange in the context of flooding and air pollution risk. We find that there is neither a one-size-fits-all nor superior format of communication. No single format is effective in fulfilling all three communication purposes. All five formats analysed appear to be successful under different circumstances and are never suitable for all segments of the population. Communication between experts and the public is difficult and full of tensions; information alone is not enough. Our study shows different ways of incorporating strategies to build trust between experts and the public and make communication more fun and accessible, breaking down hierarchies and creating safe spaces for co-creation where everyone feels empowered to participate and everyone benefits.

1 Introduction

Flooding and air pollution represent serious concerns for many urban populations worldwide and are aggravated, for example, by climate change, growing populations, and increasing urbanisation (Committee on Climate Change, 2016; World Economic Forum, 2016). The localisation of flooding and air pollution impacts imparts responsibility jointly upon local governments, citizens, and other relevant stakeholders (Butler and Pidgeon, 2011; Johnson and Priest, 2008). Citizens should be instrumental in driving local solutions and in tackling these two environmental challenges. Not only do citizens possess highly pertinent local and personal on-the-ground experience and knowledge, but also when they are aware and prepared they become key to limiting the dam- age that a specific hazard brings to people, the economy, and the environment (Bickerstaff, 2004; Burningham et al., 2008; Environment Agency, 2001; O'Hare et al., 2016).

Through a systematic review, we have selected and analysed 50 articles on two-way communication between experts and the public in the context of flooding and air pollution. For the first time, we offer a comparison of how five different communication formats can be used for dealing with incidents, raising awareness, and promoting knowledge exchange; we also explore differences in communication possibilities between these two different hazards.

The awareness and preparedness campaigns for flooding and air pollution have followed the premise that if citizens have information, they will be aware, prepared, and ready to take action (Bickerstaff, 2004; Burningham et al., 2008). This aligns with a "deficit model" in which citizens are pas-

sive receivers of information and experts fill the knowledge gap through a one-way form of communication to the public (Miller, 2001). However, citizens are not passive receivers of information; they are active, critical, have values and beliefs, and possess lay knowledge as well as relevant previous experiences (Longnecker, 2016), in this case, of floods and the effects of air pollution. One-way provision of information does not, therefore, realise the full potential of knowledge transfer. The discrepancies in information on people's personal experiences of flooding or air pollution, together with an excessive use of technical language and the challenge of presenting ambiguity and uncertainty in complex topics, are some of the factors that can debilitate the communication process (Bickerstaff, 2004; Bickerstaff and Walker, 1999; Burningham et al., 2008). The existing climate of mistrust between the public and (some) experts is another factor that can limit the effectiveness of communication (Bickerstaff, 2004; Goodwin and Dahlstrom, 2014; Slovic, 1999; Weingart and Guenther, 2016). The government and the media, for instance, are not seen as being very trustworthy, mostly due to a suspicion about their respective political agendas, which may be at odds with doing their best for the public good (e.g. Bickerstaff, 2004; Bickerstaff and Walker, 1999).

Promoting local perspectives and on-the-ground experiences and facilitating knowledge exchange between experts[1] and non-experts is key in reducing risks associated with flooding and air pollution, but a challenge nonetheless. Public engagement for knowledge exchange purposes has proven to be governed by an incapacity to create a non-hierarchical and safe space for co-creation in which the public feels empowered to contribute knowledge and the experts are dissociated from the authoritarian figure (Whatmore and Landström, 2011). Genuine knowledge exchange requires a "substantial" approach to public engagement, in order to "improve the quality of decision-making, to create more socially robust scientific and technological solutions" (Wilsdon and Willis, 2004, p. 39). In this approach, active citizens are subjects rather than objects in the governance of science and technology. Specifically, substantial public engagement would require (1) a public that is encouraged to deliberate jointly with the experts in contrast to only being allowed to voice an opinion; (2) agreement that the goal is to reach consensus between the two (or more) parties involved, and not just exploring different views; (3) breaking knowledge hierarchies and actively promoting the experiences, opinions, and agendas of experts and non-experts equally; and (4) inclusion of under-represented groups or groups who usually hold more critical, strong, and dissimilar views (Wilsdon and Willis, 2004, p. 39). In other words, if participation is not to be an empty and vacuous process it must come hand-in- hand with a redistribution of power. Levels of participation have been represented by the metaphor of a ladder. On the first rungs, there are efforts to educate people. These are followed by citizen consultation initiatives, where citizens have a say, but where it is uncertain how, or whether, those views are incorporated. The highest rung represents citizen control, beyond an equal partnership with traditional power holders (Arnstein, 1969). This highest form of participation may be expressed in terms of partnership between citizens and traditional power holders, when the process becomes a negotiation.

Central to this line of work is the need to move away from one-way provision of information and explore how two-way communication can be established. There is a need to examine which two-way communication formats are available, and to ascertain which of these are more suitable for rais- ing awareness and which would allow substantial engage- ment and expert–public knowledge partnerships. It is also important to identify and investigate the actors of two-way communication processes, and those who initiate or control these communication processes. Whilst several recent studies have focused on one communication format in particular (e.g. Bosschaart et al., 2016; Breuer et al., 2017; Leon et al., 2015; Lo et al., 2013; Sîrbu et al., 2015) and on ei- ther flooding or air pollution individually – with some exceptions combining multiple hazards (Rodriguez Bermúdez et al., 2015) – our systematic review offers an overview of possibilities. This study offers a comparison across five different formats embracing two very different hazards: flooding and air pollution. Flooding is discrete in time, visual, and tangible as it has direct consequences on people and infrastructure, whereas air pollution is more difficult to grasp as it is a continuous threat, generally invisible in many urban centres, and has non-immediate health impacts. Different studies show how sensory cues (visual or olfactory) are necessary for people to relate to the otherwise intangible air pollution (e.g. Bickerstaff and Walker, 2001). Studies also explain how participants who link flooding to climate change are more likely to relate to this issue, due to the invisibility of climate change and the visibility of flooding (e.g. Whitmarsh, 2008).

1 Two-way communication in flooding and air pollution: a systematic review

2.1 Search strategy

Systematic reviews have become an increasingly popular research method in relation to climate change. In such a review a study pool is created based on a well-defined search protocol and a set of inclusion and exclusion criteria (Boland et al., 2013; Ford et al., 2011; Groulx et al., 2017; Lumbroso et al., 2017; Petticrew and Roberts, 2005). The metadata searches for this systematic review were conducted in two large and multidisciplinary academic databases: Scopus and Web of Science. This review emulates the technique used by Groulx et al. (2017), as their analysis of the different learning outcomes of citizen science projects is similar in approach to

[1] By experts we include anybody who investigates, works with, or manages flooding and air pollution.

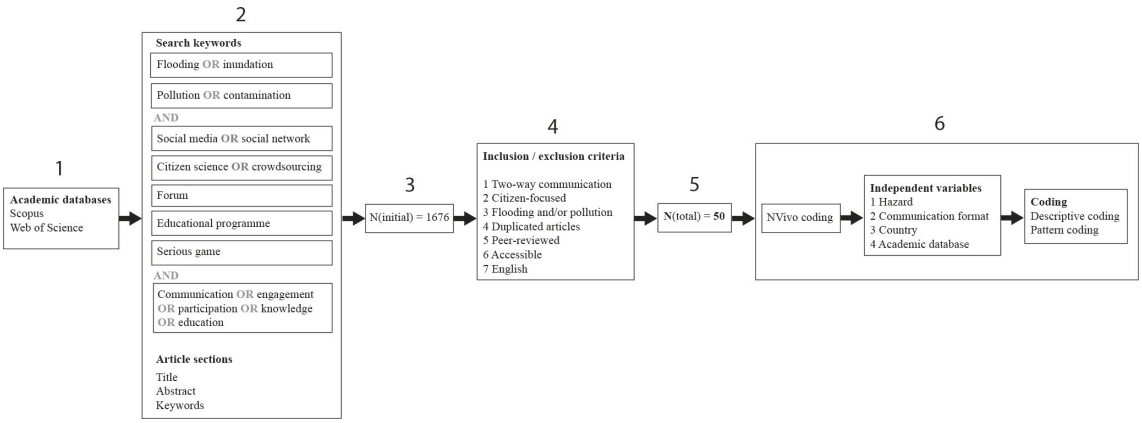

Figure 1. Overview of the systematic review methodology, stating (1) in which academic databases the search was conducted, (2) the different selected search keywords and in what parts of the articles the search keywords were looked for, (3) the initial number of retrieved articles, (4) the applied inclusion and exclusion criteria, (5) the final number of articles to be analysed, and (6) the coding exercise.

our aim of investigating communication outcomes of different two-way communication formats. The process followed in the systematic review is outlined in Fig. 1.

Our systematic review was limited to formats that allow two-way communication, where there are two "communicators" who issue and receive information (Bowater and Yeoman, 2012). Two-way communication can take many forms, but for the purpose of this review we accepted anything from face-to-face dialogues, to communication composed through posts and comments in social media. These formats include social media, educational programmes, discussion forums (collaborative encounters where experts work closely with affected communities; Whatmore and Landström, 2011), serious games (those which exceed mere entertainment purposes and also intend to educate; Abt, 2002), and citizen science projects, which can be described as "collaborative research that involves members of the general public (or citizens), and which actively involves them collecting, generating, and analysing data" (Illingworth and Allen, 2016, pp. 5–12). This list of formats was informed by an initial litera- ture review of the field (Amri et al., 2017; Aubert et al., 2015; Fohringer et al., 2015; Gravina et al., 2017; Mani et al., 2016; McCormick, 2012; Pennington et al., 2015; Salvati et al., 2016; Whatmore and Landström, 2011), and in dis- cussion with stakeholders in urban risk management, namely the Association of Greater Manchester Authorities (AGMA). The initial literature review also revealed that the search strategy had to account for terminological synonyms and alternative denominations. For example, "flood" is often used interchangeably with "inundation". Finally, the literature review elucidated that other terms had to be considered together with "communication", such as engagement, participation, knowledge, and education. Search keywords were linked using the Boolean operators AND/OR, and search was programmed to retrieve articles containing these search terms in the title, abstract, and keyword sections.

2.2 Article inclusion criteria

Not all the articles retrieved in these searches were relevant and thus a set of seven inclusion criteria was designed (Fig. 1, box 4):

- Criterion 1 (two-way communication) was designed to include only articles addressing two-way communication. For example, articles dealing with flyers and leaflets in mailboxes as educational propaganda were retrieved under the term "educational programmes", but these formats do not permit interaction between experts and non-experts.

- Criterion 2 (citizen-focused) ensured that articles were only included where they explained how the communication process impacted the citizen. For example, explaining how participants became more aware of a risk or how their input was incorporated into policy. Articles dealing with data mining, in which users do not realise that their data were being taking into consideration, were discarded.

- Criterion 3 (flooding and/or pollution) was included so that only articles dealing with flooding and air pollution were selected. Sometimes, other types of pollution, such as water pollution, came up. Additionally, HIV prevention campaigns were retrieved under the category "contamination" (terminological synonym of pollution) although they were not relevant for our study.

- Criterion 4 (duplicated articles) removed duplicate articles. Some of the articles came up under two different

communication formats when these were used simultaneously, and had to be removed from the secondary category.

- Criterion 5 (peer-reviewed) assessed whether the article was published in academic and peer-reviewed literature.
- Criterion 6 (accessible) was related to accessibility, and how the articles had to be either open-access, available through the Manchester Metropolitan University library, or fully and freely accessible through ResearchGate via author elective uploads.
- Criterion 7 (English) ensured that only articles written in English were considered.

2.2 Coding the articles

The articles were coded for qualitative data analysis using the NVivo software. All the articles were assigned four independent variables: country, hazard (flooding or air pollution), format of communication (social media, serious games, educational programmes, citizen science, or forums), and academic database (Scopus or Web of Science). The coding exercise was developed in two cycles. Firstly, the data were analysed through a method called "descriptive coding", which allows the attribution of a label that describes the basic theme of a paragraph. Secondly, the data were later re-coded using a method called "pattern coding" (Saldana, 2009), finding relationships between codes and grouping data into more meaningful units. The coding exercise took place first with the articles retrieved from Scopus, and the articles in Web of Science were used to prove data saturation (Bryman, 2012).

All the articles analysed in the systematic review can be found in Table 1.

3 Results of the systematic review

3.1 Social media: incident-related knowledge exchange, response coordination, and raising awareness

Social media can be used for short-term communication in the case of an imminent or ongoing incident, such as flooding (e.g. Bunce et al., 2012) or air pollution crisis (e.g. Zhang et al., 2014). Most examples which involve emergency communication come from flooding and only relatively few from air pollution. Most often, air pollution is an ongoing problem and thus social media is used with a long-term focus (e.g. Fedorenko and Sun, 2016).

The articles show that when social media is used for short-term communication, it can be done so with three different aims. (1) It can be used to share warnings and information in relation to an incident. For example, during the 2011 Queensland (Australia) floods, the Queensland Police Service used their Facebook page as the main channel for emergency communication, allowing citizens to "access, post and share information about road closures, flood peaks", etc. (Bunce et al., 2012, p. 37). Similarly, during the flooding in Thailand in 2011, social media was used for sharing information and advice on how to behave and what actions to take either from other more experienced citizens or from official sources: "victims shared the photos of their homes and the flood, and the knowledgeable ones uploaded their advice and analysis about the situation" (Leong et al., 2015). (2) Social media can also be employed by experts (e.g. government officials or response teams) to communicate with affected citizens and neighbours and collect on-the-ground information regarding the situation during and after a flooding incident, which can help provide a more accurate response to the situation (Rizza and Pereira, 2014; Yadav and Rahman, 2016). Social media is also used by affected populations to share emotions, and consequently by government officials to observe citizens' physical and psychological well-being during a crisis. During the 2013 Southeast Asian Haze, for example, social media allowed the acquisition of information from the general population in this regard, which is key in determining how citizens are coping (Zhang et al., 2014). (3) Social media has also proven to be useful for coordinating response to a crisis. For example, it can be used to ask for donations, provide help, or to gather supplies such as temporary accommodation or food (Wan Hussin et al., 2016).

Social media can also be used with a long-term focus, in order to raise awareness about key issues (Roshandel Arbatani et al., 2016). The air pollution movement in China (2011–2012), for instance, used social media for "illustrating the size and impacts of particulate matter in accessible ways" (Fedorenko and Sun, 2016). Social media is also a valuable medium to encourage attitudinal and behavioural change, for example, through sharing adaptation strategies and measures that citizens can adopt to tackle air pollution (Kay et al., 2015). Alternatively, social media can function as an effective platform to encourage debate between experts and community members. In the aftermath of the 2011 Thai flood crisis, social media was used to "share compassionate stories, obtain emotional and physical support from their peers" which helped in the recovery process (Kaewkitipong et al., 2016). Finally, social media can also be employed to campaign in relation to an environmental injustice or problem, fostering collective action, group identity, and a sense of belonging to a community (Xu, 2014). This last usage of social media is especially relevant for countries, such as China, where public gatherings of any political nature are prohibited.

Social media facilitates an important three-way process. In social media, downstream approaches from experts to the public coexist with "horizontal interactions" between citizens (Fedorenko and Sun, 2016), alongside an upstream approach where citizens take the lead: "the power previously contained in the hands of government agencies shifts to the people" (Leong et al., 2015, p. 193). In the face of this democratisation in the communication process, different studies highlight the importance of having a person or a

Table 1. A list of the 50 articles analysed in the systematic review. Each article is accompanied by the following information: authors, title, country in which the communication was implemented, the environmental hazard it relates to, and the main communication format it focuses on.

Authors	Title	Country	Environmental hazard	Communication format
Aisha et al. (2015)	Exploring the Use of Social Media During the 2014 Flood in Malaysia	Malaysia	Flooding	Social media
Al-Saggaf and Simmons (2015)	Social media in Saudi Arabia: Exploring its use during two natural disasters	Saudi Arabia	Flooding	Social media
Bormann et al. (2012)	Adaptation of water management to regional climate change in a coastal region – Hydrological change vs. community perception and strategies	Germany	Flooding	Forum
Bosschaart et al. (2016)	Designing a flood-risk education program in the Netherlands	The Netherlands	Flooding	Educational programme
Bosschaart et al. (2016)	Evaluating a flood-risk education program in the Netherlands	The Netherlands	Flooding	Educational programme
Breuer et al. (2017)	Exploring the application of a flood risk management Serious Game platform	Germany	Flooding	Serious games
Bunce et al. (2012)	Exploring information experience using social media during the 2011 Queensland floods: A pilot study	Australia	Flooding	Social media
DeForest Hauser et al. (2015)	Passive samplers and community science in regional air quality measurement, education and communication	USA	Air pollution	Citizen science
Demir (2014)	Interactive web-based hydrological simulation system as an education platform	USA	Flooding	Educational programme
Elnokaly et al. (2008)	Engaging architects and architectural students in global warming awareness	Egypt	Air pollution	Educational programmes
Fedorenko and Sun (2016)	Microblogging-Based Civic Participation on Environment in China: A Case Study of the PM 2.5 Campaign	China	Air pollution	Social media
Felicio et al. (2014)	Stop disasters game experiment with elementary school students in Rio de Janeiro: Building safety culture	Brazil	Flooding	Serious Games
Fritze and Kray (2015)	Community and governmental responses to an urban flash flood	Germany	Flooding	Social media
Jiao et al. (2015)	Application of citizen science risk communication tools in a vulnerable urban community	USA	Air pollution	Citizen science
Kaewkitipong et al. (2012)	Lessons learned from the use of social media in combating a crisis: A case study of 2011 Thailand flooding disaster	Thailand	Flooding	Social media
Kaewkitipong et al. (2016)	A community-based approach to sharing knowledge before, during, and after crisis events: A case study from Thailand	Thailand	Flooding	Social media
Kay et al. (2015)	Can Social Media Clear the Air? A Case Study of the Air Pollution Problem in Chinese Cities,	China	Air pollution	Social media
Kongthon et al. (2012)	The role of Twitter during a natural disaster: Case study of 2011 Thai Flood	Thailand	Flooding	Social media
Kongthon et al. (2014)	The role of social media during a natural disaster: A case study of the 2011 Thai flood	Thailand	Flooding	Social media
Le Coz et al. (2016)	Crowdsourced data for flood hydrology: Feedback from recent citizen science projects in Argentina, France and New Zealand	Argentina, France, New Zealand	Flooding	Citizen science

Table 1. Continued.

Authors	Title	Country	Environmental hazard	Communication format
Leong et al. (2015)	ICT-enabled community empowerment in crisis response: Social media in Thailand flooding 2011	Thailand	Flooding	Social media
Lo et al. (2013)	Reciprocity as deliberative capacity: Lessons from a citizen's deliberation on carbon pricing mechanisms in Australia	Australia	Air pollution	Forums
Mackay et al. (2015)	Digital catchment observatories: A platform for engagement and knowledge exchange between catchment scientists, policy makers, and local communities: DIGITAL CATCHMENT OBSERVATORY: AIDING STAKEHOLDER ENGAGEMENT	UK	Flooding	Citizen science
Mao and Pan (2014)	Constructing the cultural repertoire in a natural disaster: The role of social media in the Thailand flood of 2011	Thailand	Flooding	Social media
McCallum et al. (2016)	Technologies to Support Community Flood Disaster Risk Reduction	China	Flooding	Social media
McCormick (2012)	After the cap: Risk assessment, citizen science and disaster recovery	USA	Air pollution	Citizen science
Moreno Ramírez et al. (2015)	Pollution Prevention through Peer Education: A Community Health Worker and Small and Home-Based Business Initiative on the Arizona-Sonora Border	USA	Air pollution	Educational programmes
Naik (2016)	A crowdsourced sensing system for disaster response: A case study	China	Flooding	Citizen science
Ngo et al. (2017)	Why participation matters for air quality studies: risk perceptions, understandings of air pollution and mobilization in a poor neighborhood in Nairobi, Kenya	Kenya	Air pollution	Forums
Rebolledo-Mendez et al. (2009)	Societal impact of a serious game on raising public awareness: The case of FloodSim	UK	Flooding	Serious games
Rijcken et al. (2012)	"SimDelta" – Inquiry into an Internet-Based Interactive Model for Water Infrastructure Development in The Netherlands	The Netherlands	Flooding	Serious games
Rizza and Pereira (2014)	Building a resilient community through social network: Ethical considerations about the 2011 Genoa floods	Italy	Flooding	Social media
Rodriguez Bermúdez et al. (2015)	ECity: Virtual city environment for engineering problem based learning	Europe	Air pollution	Serious games
Roshandel Arbatani et al. (2016)	Effects of Social Media on the Environmental Protection Behaviour of the Public (Case Study: Protecting Zayandeh-Rood River Environment)	Iran	Air pollution	Social media
Rothkrantz (2016)	Flood control of the smart city Prague	Czech Republic	Flooding	Serious games
Salvati et al. (2016)	Communication strategies to address geo-hydrological risks: the POLARIS web initiative in Italy	Italy	Flooding	Social media
Santos et al. (2012)	Changing environmental behaviors through smartphone-based augmented experiences., 2012	Portugal	Air pollution	Educational programmes
Savic et al. (2016)	Serious gaming for water systems planning and management	The Netherlands	Flooding	Serious games
Senaratna et al. (2013)	Natural hazards and climate change in Kenya: Minimizing the impacts on vulnerable communities through early warning systems	Kenya	Flooding	Forums

Table 1. Continued.

Authors	Title	Country	Environmental hazard	Communication format
St. Denis et al. (2014)	Mastering social media: An analysis of Jefferson County's communications during the 2013 Colorado floods	USA	Flooding	Social media
Starkey et al. (2017)	Demonstrating the value of community-based ("citizen science") observations for catchment modelling and characterisation	UK	Flooding	Citizen science
Wan Hussin et al. (2016)	Knowledge sharing via online social media during flood disaster events: A review	Australia	Flooding	Social media
Ward et al. (2016)	Air Toxics Under the Big Sky: examining the effectiveness of authentic scientific research on high school students' science skills and interest	USA	Air pollution	Educational programmes
Whatmore and Landström (2011)	Flood apprentices: an exercise in making things public	UK	Flooding	Forums
Wister et al. (2016)	Emergency population warning about floods by social media	Unspecified	Flooding	Social media
Xu (2014)	Communicating the right to know: Social media in the do-it-yourself air quality testing campaign in Chinese cities	China	Air pollution	Social media
Yadav and Rahman (2016)	The social role of social media: the case of Chennai rains-2015	China	Flooding	Social media
Zhang et al. (2014)	Usage of social media and smartphone application in assessment of physical and psychological well-being of individuals in times of a major air pollution crisis	Southeast Asia	Air pollution	Social media

team dedicated to managing social media communications, before, during, and after a crisis. Constant interaction as well as tirelessly responding to questions and comments is key to counteracting misinformation and rumours with real and valid information (Wan Hussin et al., 2016; Xu, 2014). The fact that anyone can post information on social media, and that there is no quality control over what gets posted, can be a limitation inherent to this medium. People receiving incorrect information on how to behave during a flood, or people taking advantage of flood incidents by failing to pass on donations to victims are two examples of such a limitation (Wan Hussin et al., 2016). On a more practical basis, different studies highlight the importance of using hashtags to help channel the discussion and the communication efforts to relevant people or to interested parties (St. Denis et al., 2014). Additionally, social media appears to be a medium for concise and brief information. Twitter in particular has a character limit on tweets and it is commonplace to find messages containing links to external resources and more detailed information (St. Denis et al., 2014).

3.1 Education programmes: raising awareness

If the systematic review found that social media is suitable for short- and long-term communication, then educational programmes are used solely with a long-term focus, namely, to raise awareness or promote a certain behaviour. An educational programme implemented in Arizona, for example, was designed to help home-based and hard-to-reach businesses (e.g. a beauty salon or a printers) in becoming green. The aim was to help them transition towards less-toxic substances, as well as to encourage these professionals to reuse and recycle materials (Moreno Ramírez et al., 2015). In the Netherlands, an educational programme had the aim of improving the understanding of hydrological concepts, and enhancing preparedness intentions of 15-year-old students (Bosschaart et al., 2016; Demir, 2014).

Educational programmes appear to follow a downstream approach, meaning that although communication flows from expert to public and vice versa, it is the experts who initiate the communication process, that is, the ones to design, organize, and set up the educational programme. Different studies agree on the benefits of implementing these programmes with the help of opinion leaders, that is, figures who are respected, perceived as being knowledgeable, and who hold higher levels of trust than, for instance, government officials. Opinion leaders are usually close, or have access, to the community or segment of the population at which the programme is aimed. In the programme implemented in Arizona, female Hispanic community health workers (called "promotoras") were invited to run the programme. They possess leadership skills that allow them to effectively influence their commu-

nity (Moreno Ramírez et al., 2015). They are trusted because they have been trained in public health issues, and because they are "indigenous to the community" (Moreno Ramírez et al., 2015). Sometimes, the figure of the opinion leader is interchanged with that of a mediator. In cases where the programme is designed to be implemented in schools, for example, school teachers become mediators, whose job it is to guide the learning (e.g. Bosschaart et al., 2016), and the experts behind the programme design (e.g. scientists or local governments) remain as an available resource throughout the programme. It is commonplace that these intermediaries receive specific training on how to run the programme. In the case of the "promotoras", for instance, they received expert training and necessary materials to provide real-world application for specific business needs that can translate into positive change (Moreno Ramírez et al., 2015).

Educational programmes are characterised as being highly interactive. This interactivity is sometimes achieved by incorporating virtual reality technology, allowing visualisations, simulations, and animations that allow people to observe, say, different flooding scenarios and their consequences in real time (Demir, 2014), which would be impossible in real life but are important for learning (e.g. Demir, 2014). In other examples, educational programmes include inquiry- based education where students are provided with equipment and training for air sampling, followed by modules address- ing air pollution and health outcomes (Ward et al., 2016). Interactivity was also at the heart of another educational programme based in a school, in which pupils used old newspapers, toys, bottles, etc. from their homes to create an artwork and work with the concepts of reusing and recycling (Elnokaly et al., 2008). Another key feature of educational programmes is that often they employ real information, such as real-time flood conditions or inundation maps (Demir, 2014). Additionally, the systematic review shows that educational programmes need an element of fun, have to be easy to develop, and should offer the appropriate training when more technical knowledge is involved.

3.1 Serious games: raising awareness

Just as with educational programmes, serious games are reserved for long-term communication, to increase awareness and understanding, especially around flooding. For example, the aim of the game "Stop Disasters" is to work with concepts of resilience and resistance (Felicio et al., 2014). In "FloodSim", players implement a selection of strategies for addressing the risk of flooding based on a pre-defined budget. The game is designed to encourage players to think about what type of barriers to build, which regions to concentrate on, how much funding to allocate to maintenance, what warning systems to establish, etc. (Breuer et al., 2017).

Although serious games can be a vehicle for learning and communication in themselves (Felicio et al., 2014), they are sometimes accompanied by discussion and debate and played in classroom settings, where the teacher guides debate, answers questions, and explains concepts (Rodriguez Bermúdez et al., 2015). But the usage of serious games goes beyond schools and face-to-face workshops or events, where the debate is guided by experts (e.g. scientists). Sometimes, debate can also take place in a mediated environment, such as a blog or a wiki (Rodriguez Bermúdez et al., 2015). Although serious games allow two-way interactions between experts and non-experts, they tend to follow a top-down approach to communication. That is, experts are behind the game de- sign and decide what content and information is included, which will, in turn, guide the concepts to be discussed with the non-experts. The United Nations, flood risk management professionals, and scientists in different universities are some of the people involved in designing serious games who may or may not be involved later in playing the game (e.g. Felicio et al., 2014; Savic et al., 2016). Some of the studies discuss the need for closer collaborations between game developers and knowledge partners so that games more closely fulfil the objective of raising awareness (Rebolledo-Mendez et al., 2009).

Different studies agree on the importance of having a binomial fun–knowledge combination. That is, the player has to be engaged, but acquiring new knowledge needs to be a requirement for success in the game: "the game can neither be a simple funny game without any learning, nor only involve difficult concepts without any incentive" (Rodriguez Bermúdez et al., 2015, p. 162). Including random features so that the flow of events can not be predicted or offering a diversity of scenarios are some of the strategies employed to keep the player engaged (Rodriguez Bermúdez et al., 2015). In order to make sure that the player is learning and mak- ing informed decisions, supporting information can be integrated into the game. For example, in eCity, players can get a short explanation of the advantages and disadvantages of possible moves (Rebolledo-Mendez et al., 2009). It seems as if educational programmes are designed to educate but need to have an element of fun, and serious games are fun but need to educate. Additionally, serious games appear to be an effective tool for improving understanding, as they of- fer continuous feedback to the player, avoiding the formation of misconceptions (Savic et al., 2016). They also encourage active and experiential learning, allowing players to handle datasets, modify values, and experience simulations which would be impossible or very expensive in real life (Breuer et al., 2017).

3.2 Citizen science: raising awareness and long-term knowledge exchange

Citizen science is also used for long-term communication, but appears to have a broader usage than that of educational programmes and serious games. Citizen science is helpful in raising awareness, but is also employed to facilitate knowledge exchange between experts and the public. "AirProbe"

is a project that aims to raise awareness about air pollution by involving citizens in measuring air pollution in their daily life. The AirProbe project shows that involving citizens in taking measurements can be very effective in producing a positive change (Sîrbu et al., 2015). When citizen science projects aim at raising awareness, they tend to follow a downstream approach, initiated by the experts.

Citizen science projects, however, are also employed to facilitate knowledge exchange between experts and the public, or to complement or challenge expert knowledge. For example, they can be useful in gathering knowledge that would be impossible for experts alone to collect in terms of amount and accessibility. In the case of the Deepwater Horizon oil spill, a citizen science project was developed to allow citizens contribute with information of what they saw and smell, such as "smells, smoke, and other potential risk factors", which can in turn be used in decision-making and in complement- ing expert science (McCormick, 2012, p. 2). Furthermore, as experts and the public often work together in these projects, exchange knowledge, and discuss scientific data – as opposed to just receiving the outcomes generated by experts alone – these projects have become a means of improving communication and the levels of trust in each other (Ngo et al., 2017; Thiel et al., 2014).

Across studies we find that affected or concerned citizens, who suffer the consequences of flooding or air pollution first hand, are more inclined to participate in these projects. For example, a community that is affected by a flood has more at stake, and therefore, is more inclined to produce citizen scientists and share flood observations (Le Coz et al., 2016). Similarly, residents who live nearer facilities that emanate or contain environmental contaminants are more likely to perceive the benefits of participating in a citizen science project aimed at improving their situation (Jiao et al., 2015). Learning about the environment is also another motivation to join citizen science projects, which broadens the spectrum of participants from affected communities to society at large. Schools are sometimes also involved in these projects, integrating them in their science curriculum (e.g. Sîrbu et al., 2015). All segments of the population, however, are never equally empowered to participate. For example, projects involving technology, such as social media or Dropbox (Le Coz et al., 2016), will inevitably add to the digital divide.

There are two factors that appear to be essential in citizen science projects. First, most of the studies concur that the first stage of any of these projects should involve training, and finding common ground between all the participants. Citizen science projects have a greater chance of fulfilling the established aims, if participants understand the ultimate aim of the project, how they can contribute and gain the most, how to use the necessary tools appropriately (e.g. air pollution measuring devices), and who to address if they encounter setbacks or need clarifications. Citizen science seems to work better when there is a clear and common goal for every participant involved, when beneficial outcomes for all are set (Jiao et al., 2015). Learning about data collection, creating bonds with other community members, or simply having an enjoyable experience are some of the examples that exceed the most obvious strategic goals usually coupled to these projects (e.g. improving flood management). Second, most of the studies highlight the importance of feeding back the results to the group after the completion of the project. Participants must understand the overall impact of the project and how their contributions fit within it, as well as how the project, the data, and the results are going to be employed (Le Coz et al., 2016).

3.1 Forums: long-term knowledge exchange

Discussion forums are used for long-term communication. They are the only medium solely used for knowledge exchange practices, and to bring together local and scientific knowledge. Slightly more examples of forums are found in relation to flooding than to air pollution. In Kenya, for example, a forum was organised by climate experts in order to seek traditional knowledge and build flood early warning systems: "local farmers are witnesses of their own environment and the first to notice changes and potential risks" and thus, "open dialog is necessary to build climate products that reflect farmers' needs in terms of warnings" (Senaratna et al., 2013, p. 11). Another air pollution forum, also in Kenya, explored how academics and local residents together could design action points to tackle the air quality issue (Ngo et al., 2017).

Forums can follow a downstream or upstream approach: they are sometimes initiated by experts who believe in the benefits of exploring the ground reality and local knowledge, or by the public who feel threatened and ignored, and consequently take action. Discussion forums are not always representative of the whole population, as participants usually belong to segments of the population that feel more empowered to participate (e.g. people with higher levels of education). Therefore, community members who participate in these forums are then in charge of passing on the information to the rest of the community. For example, if a forum deals with how to tackle flooding at the community level, the group is then in charge of preparing their community to face a possible flooding event, by organising meetings and developing training to raise awareness and prepare the community for evacuation and rescue plans (Senaratna et al., 2013).

Discussion forums are, however, a challenge, and on many occasions they begin with "palpable tension apparent" (Lo et al., 2013, p. 9). This tension can be attributed to a lack of trust in the experts, an incapacity to break down hierar- chies of power and to encourage non-experts to contribute, or to the all too often technical language employed by the experts, which distances them from the public. Therefore, different studies deal with how to ease tensions. We have, consequently, identified four strategies for doing so. The first strategy involves experts and non-experts making something

together, the benefits of which are two-fold: making something together works as a *process*, as a facilitatory medium taking the focus away from anything that generates tensions; but it also works as a *product* in order to engage the wider community when this is presented, for example, in an exhibition at the community centre, or is showcased in the community hall (Leon et al., 2015). The second strategy is found in one of the forums in the UK, which encourages participants to bring objects (e.g. maps, photos, satellite images, and even a piece of mouldy carpet) that show their connection to a flooding event, which works toward highlighting each member's connection to it (Whatmore and Landström, 2011). The third strategy is inspired by citizen science projects, through which the non-experts collect data that later guide the discussion and debate process. Asking participants to take personal exposures to particulate matter (PM), can be a starting point for the latter discussion and can aid the non-expert in building and supporting their arguments (Ngo et al., 2017). The last strategy consists of initiating the forums with an informative session. In one of the forums, for instance, specialists were invited to set the grounds for the debate, sharing information about the scientific, economic, and political implications of climate change and carbon tax. This was followed by an opportunity to respond to specific queries, and lastly participants were able to design a preferred carbon pricing policy (Lo et al., 2013).

A visual comparison of the results for all five communication formats can be found in Fig. 2.

Finally, these five formats are sometimes combined in order to facilitate their implementation and offer a more positive engagement. Sometimes educational programmes and serious games employ social media as a platform to enable discussion (e.g. Rodriguez Bermúdez et al., 2015). Citizen science initiatives also use social media, not only to facilitate discussion during the project, but also to recruit participants, answer questions, and feedback the results to the group (e.g. Le Coz et al., 2016). In some instances, citizen-science-style activities can be developed as part of educational programmes to improve learning (e.g. hands-on activities, place-based learning) (e.g. Ward et al., 2016). Similarly, citizen science can also be employed as a strategy to empower citizens in their discussion and collaboration with the experts (e.g. Ngo et al., 2017). The way these can be combined also points out that social media and citizen science projects are the two most versatile formats. A visual representation of the combination of formats can be found in Fig. 3.

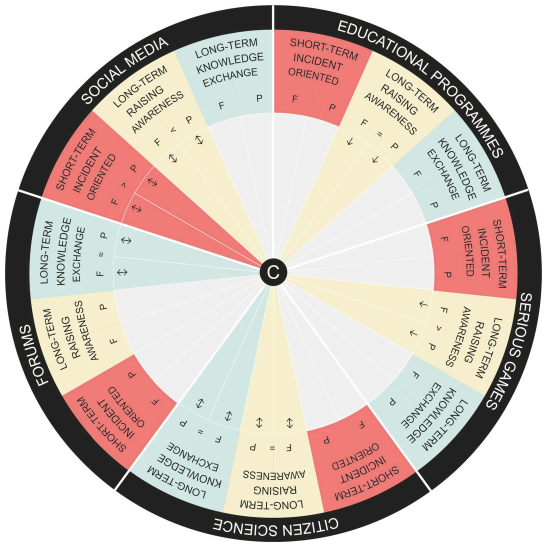

Figure 2. A comparison of how social media, educational programmes, serious games, citizen science, and forums can be used for flooding (F) and air pollution (P) risk. It shows whether these formats allow short-term communication, in relation to an ongoing or imminent *incident*; or whether it is long-term, and for *raising awareness* or for *knowledge exchange* purposes. It also shows when examples of either air pollution or flooding are more prominent than the other (<, >), and if these communication formats suit both hazards to the same extent (=). The grey zones represent incompatibility of the medium and usage. The arrows represent direction of communication, that is, whether communication is top-down ( ) and initiated by the experts, or if it can also be bottom-up ( ) and initiated by the public and experts alike.

4 Conclusions

This systematic review shows that there is no one-size-fits-all format of communication, and that the suitability of each medium is tied to the communication purpose and the people involved. Emergency communication needs the immediacy and remoteness of social media, whether it is to exchange knowledge about the crisis or to coordinate a response. Expert–public partnerships for knowledge exchange purposes, on the other hand, need face-to-face encounters through forums that allow discussion and negotiation. In these two instances, the public is emotionally invested and can demand upstream approaches to communication where they can initiate the process. Raising awareness and preparedness of the population can be done through multi- ple media: Social media, educational programmes, serious games, and citizen science. These communication efforts are always led by experts, following a downstream approach. It is understandable that citizens would rarely demand that they are "educated", thus the lack of upstream approaches coupled to awareness-raising communication efforts. Returning to the metaphor of the ladder (Arnstein, 1969), it would seem as if only the highest forms of engagement – represented in the higher rungs – allowed upstream approaches.

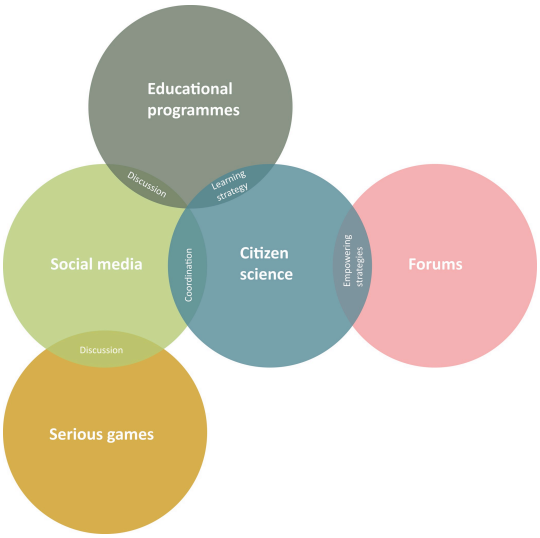

Figure 3. A visualisation of how social media, serious games, educational programmes, citizen science, and forums are currently being combined, and for what purposes.

These formats are never suitable for all segments of the population. If social media is the most democratic, it still adds to the digital divide impeding, for example, the participation of older generations. Educational programmes, for instance, target conglomerates such as schools or sector professionals, and hence these require different designs and modes of implementation. Forums, for instance, invite members of affected communities, specifically those who feel confident in meeting face-to-face with experts, and they in turn become the new experts in their communities and in charge of reaching the harder-to-reach groups in that community. Following Davies (2014) and Harvey (2008), perhaps the fact that these formats can never target society at large and that some groups tend to be excluded from these communication encounters can be understood as a call to open up the door for non-discursive aspects (e.g. objects), aspects that will move the focus away from reasoned argument and strategic outcomes alone, and invite more diverse publics into play, where success can also be measured in terms of the experiences these encounters elicit. Opening up to forms of engagement that are more inclusive and representative is also a requirement of the "substantial" approach to public engagement previously discussed (Wilsdon and Willis, 2004).

The role of the opinion leaders or mediators is another interesting aspect. This phenomenon seems to be in line with the two-step flow of communication first proposed by Katz and Lazarsfeld (1966). Although this model of communication explains how ideas flow from mass media to opinion leaders, and from them to the sectors of the population that are less active, we also think it can be used to describe the flow of ideas from the experts to opinion leaders (e.g. community members involved in forums), to those least active segments (e.g. community members who do not feel empowered to participate). Although this seems to fulfil the purpose of trust issues, we anticipate that this might lead to governments, local authorities, or operating authorities passing on responsibility with the danger of destabilising an appropriate balance of responsibility distributed across multiple stakeholders, including the government and affected citizens. According to Johnson and Priest (2008), a shift in responsibility is already occurring: "citizens are being increasingly required to take responsibility for the management of their own flood risk at both a local community, business and individual household level" (Johnson and Priest, 2008, p. 515). They explain that those at risk need to assume the responsibility of being more prepared (e.g. household-level adaptation measures), and need to make themselves part of the decision-making in their community (e.g. flood risk management at the community level). We add that passing on responsibil- ity in communication and raising awareness might also contribute further to this phenomenon.

Our analysis supports the idea that information alone is not sufficient, that communication practices appear to be difficult, and that there is a need for strategies that will break down hierarchies and distract participants from factors that can hinder the encounter, such as previous negative experiences or the lack of trust in each other, and how this is especially accentuated when the people involved in the communication process are emotionally invested (e.g. affected communities). Our systematic review shows that a key feature of effective communication, or effective usage of the selected communication formats, is to make flooding and air pollution more accessible and engagement more fun.

In relation to the independent variables, there appear to be few differences on how communication formats are employed across countries, maybe because there are not enough articles per country for differences to emerge. The only distinction is linked to countries such as China, where public meetings of any political nature, or those aimed at questioning the established order, are prohibited, and social media, thus, becomes a mechanism for mobilisation. Differences in implementation across hazards are more prominent. Social media appears to be a more popular format of communication in relation to flooding than to air pollution. Taking a closer look at social media usage, it appears that flooding requires short-term communication to deal with an imminent or ongoing event, whereas air pollution is best suited to a long-term focus in relation to improving understanding of the issue as well as modifying behaviours towards cleaner air. Although educational programmes and serious games appear to be similar in purpose and share some aspects of their implementation (e.g. binomial fun–knowledge component), the second one seems to be more popular with respect to flooding. We anticipate that this might be because of the advan-

tages of serious games being able to have rich visualisations (flooding scenarios), which is tied to the intangibility of air pollution on the one hand, and the visibility of flooding on the other. Citizen science and forums are equally suitable for the cases of flooding and air pollution.

This systematic review offers a comparison of different two-way communication possibilities in relation to flooding and air pollution, two of the major environmental problems threatening conurbations worldwide. Its findings identify clear mechanisms to guide citizens and experts in formulating and identifying their communication needs. These findings and methodologies apply equally well whether they are in relation to flooding or air pollution or to short- or long-term communication, and whether the aim is to engage affected communities or school children.

Data availability. As this is a systematic review the underlying research data are published academic papers. The list of papers can be found in Table 1.

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Appendix 4.1

Manchester Metropolitan University

Questionnaire on public perception of environmental hazards

Q1: As a UK resident, which of these environmental hazards affect you?

[] Flooding
[] Pollution
[] Severe weather (e.g. storms, heatwaves)
[] Landslides
[] Volcanos
[] Radiation
[] Earthquakes
[] Tsunamis
[] Tornados
[] Wildfires
[] None of the above

Q2: In YOUR EXPERIENCE, have environmental hazards damaged any of the following?

[] Your health
[] Your home or business
[] Roads and infrastructure (e.g. delay in transport services, school closures)
[] Utilities (e.g. electricity, water)
[] Your local environment
[] The local economy (e.g. businesses, tourism and agriculture)
[] Nothing at all
[] Other: _____

Q3: Select how threatening the following phenomena are for you personally:

	Not dangerous	Somewhat dangerous	I don't know	Fairly dangerous	Very dangerous
Floods	[]	[]	[]	[]	[]
Migration	[]	[]	[]	[]	[]
Unemployment	[]	[]	[]	[]	[]
Landslides	[]	[]	[]	[]	[]
Terrorist attacks	[]	[]	[]	[]	[]
Volcanos	[]	[]	[]	[]	[]
Cyberattacks	[]	[]	[]	[]	[]
Pollution	[]	[]	[]	[]	[]

Q4: Environmental hazards threatening the UK are caused by:

If you think it is entirely caused by humans, select 1. If you think it is entirely caused by natural forces, select 5. If you think it is a combination of both select other numbers in the scale.

Human Activity 1 2 3 4 5 Natural Forces

Q5: Who do you think is MOST responsible for managing the impact of environmental hazards? Select ONLY THREE

[] International organisations (e.g. The United Nations)
[] The national government (i.e. the UK Government)
[] Local governments (i.e. your city council)
[] Business and Industry
[] Scientists and Researchers
[] Environmental Organisations
[] Individuals
[] Other: _____

Q6: Who do you get information about environmental hazards from?

[] Family and Friends
[] Scientists from related fields
[] The government
[] Local organisations
[] The media
[] Environmental organisations
[] Other: _____

Q7: How much do you trust the following groups when they talk about environmental hazards?

	Not at all	Not very much	I don't know	Fairly	Completely
Friends or family	[]	[]	[]	[]	[]
Scientists from related fields	[]	[]	[]	[]	[]
The government	[]	[]	[]	[]	[]
Local organizations	[]	[]	[]	[]	[]
The media	[]	[]	[]	[]	[]
Environmental organizations	[]	[]	[]	[]	[]

Q8: Where do you get information about environmental hazards from?

[] Social media
[] Newspapers
[] Radio
[] TV
[] Games
[] Special events (e.g. science festivals, exhibitions)
[] Leaflets (e.g. mailbox)
[] Specialist publications (e.g. reports, academic journals)
[] Official websites (e.g. Met Office)
[] Other: _____

Demographic questions

Q9: What are the first two/three characters of your postcode? E.g. M20 or M4: _____

Q10: How old are you?

[] < 18 [] 25 – 34 [] 50 - 80 [] I don't want to reveal this information
[] 18 - 24 [] 35 – 49 [] 80 <

Q11: What is your gender? _____

Q12: What is the highest degree or level of school you have completed?

[] No formal qualifications
[] GCSE/ O-Level
[] A-Level/ Higher/ BTEC
[] Vocational/ NVQ
[] Degree or equivalent
[] Postgraduate qualification
[] I don't want to reveal this information
[] Other: _____

Q13: Please indicate your household annual income per annum (before tax):

[] < £15,000
[] £15,000 - £24,999
[] £25,000 - £34.999
[] £35.000 - £44,999
[] £45,000 - £55,000
[] > £55,000
[] I don't want to reveal this information
[] Other: _____

Q14: I'm looking for participants to interview in more detail for this study. Please leave your email below if you would be happy to be contacted:

_____

Appendix 4.2

Manchester Metropolitan University

Informed consent for questionnaire study

Title of Project: Questionnaire on Public Perception of Environmental Hazards

Name of Researcher: Maria Loroño-Leturiondo

Information: I am conducting an investigation for my PhD at Manchester Metropolitan University, about how communication can contribute to improving the UK's capacity to prevent, cope with, and recover from air pollution. Your participation is voluntary and you are free to withdraw at any time. Although the findings will be made public in the form of articles and conference presentations, the collected data will be anonymized so that nothing can be linked to you. If you are participating in the questionnaire, you will be given the option to provide your contact details if you wish to be contacted for future participation. This information will however be kept in a separate file so that your responses cannot be linked to your email address. During the project, data will be stored in a university server password protected. After the project is finished, the anonymized data will be saved and made public in the CEDA data repository. If you have any further questions relating to this study, please contact the lead investigator:
Maria Loroño-Leturiondo: maria.lorono@stu.mmu.ac.uk

If you have read and understood the above information,
If you give permission for your anonymised data to be published and made available to other researchers,
If you agree to participate in the study,
Please proceed to the questionnaire.

Appendix 5.1

Manchester Metropolitan University

Informed consent for interviews

Title of Project: Qualitative interviews about air pollution with women in Greater Manchester.

Name of Researcher: Maria Loroño-Leturiondo

Information: I am conducting an investigation for my PhD at Manchester Metropolitan University, about how communication can contribute to improving the UK's capacity to prevent, cope with, and recover from air pollution. Your participation in this 1h long interview is voluntary and you are free to withdraw at any time. Although the findings will be made public in the form of articles and conference presentations, the collected data will be anonymized so that nothing can be linked to you. During the project, data will be stored in a university server password protected. After the project is finished, the anonymized data will be saved and made public in the CEDA data repository. If you have any further questions relating to this study, please contact the lead investigator:

Maria Loroño-Leturiondo: maria.lorono@stu.mmu.ac.uk

If you have read and understood the above information,

If you give permission for your anonymised data to be published and made available to other researchers,

If you agree to participate in the study,

Please agree to proceed with the interview.