Climate Change Management

Walter Leal Filho
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Handbook of Climate Change Communication: Vol. 3

Case Studies in Climate Change Communication

Springer

Climate Change Management

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Preface

Climate change is a very complex issue. Communication about climate change is therefore anything but a simple task and the one which needs to take into account a variety of factors. Apart from the need to provide due consideration to cultural values, traditions and lifestyles, there is a perceived need to take into account the social and economic contexts which surround people and which influence their views and perceptions on climate change. Therefore, in order to yield the expected benefits, initiatives on climate change communication need to have a sound evidence basis.

This book, titled "Case Studies in Climate Change Communication", addresses the need for peer-reviewed publications which examine and discuss practical experiences, projects and case studies surrounding communication related to climate issues. It documents and promotes experiences from researchers and practitioners on climate change communication from round of the world and illustrates a variety of approaches, methods and strategies being used today to cater for a better understanding of what climate change is and what it means to people.

We thank the authors for their willingness to share their experiences and initiatives, as well as the many reviewers who have checked and provided valuable insights to their contributions, making sure they are of the highest quality. Enjoy your reading!

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In Search of New Narratives for Informed Decisions on Climate Change Crisis in the African Drylands

Aliyu Barau and Adamu Idris Tanko

1 Introduction

Many people in the developing world are fed the news of climate change through the mainstream media which feeds in from briefs released by scientists and policymakers. People including farmers and those living in flood vulnerable cities listen and watch scenarios of climate change both local and global through the media. Nevertheless, it is hard to believe that such people clearly understand the basic terms of climate change science. Indeed, many people in the developing world lack access to climate change MOOCs—massive online open courses taught by experts in foreign languages and scientific jargons. Therefore, it is urgent to address this challenge through better means of communicating climate change concepts through integration of indigenous knowledge systems and their modern counterparts. This strategy is based on the assumption that climate plays an important role in every human society and development. Hence, the representation of climate in folklores and myths could be used to bridge gaps between local people, science communicators, and climate change science and policy community. Indeed, the increasing

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uncertainty, vulnerability, complexity and ambiguity associated with wicked challenges such as climate and global environmental change drive many scientists, engineers and innovators to explore solutions. However, the main challenge is how to communicate this in the best way to convince all stakeholders.

According to Yale University's Climate Change Communication Program,[1] Climate Change Communication (CCC) is concerned with "educating, informing, warning, persuading, mobilizing and solving this critical problem." It adds that, "[a]t a deeper level, climate change communication is shaped by our different experiences, mental and cultural models, and underlying values and worldviews." Shedding more light on this, Dulic et al. (2016) observed that climate science communication develops out of the field of science communication which aims at bringing scientific knowledge to the public arena and thus make it relevant to the everyday life. Science communication is a flexible means of engaging public informally, shaping public policy, and may involve use of arts as one of its strategies (Lesen et al. 2016). Thus, CCC has great potential contribution in addressing the current global climate change crises. Even in developed countries such as Australia, where climate change science communication is integrated into the schools' curricula, there are challenges pertaining to trusting the source of climate change information in the public domain (Boon 2014). Hence, it is important to look for holistic approach in designing CCC in way and manner that useful knowledge is disseminated to all stakeholders.

Given the successive failures to conclude global climate negotiations on fair, effective, implementable means of reducing greenhouse gas emissions, Ostrom (2010) called for the need to fast track emission reduction through efforts of individuals, families, firms, communities, and governments. Some critical scholars have also paid attention to multi-scalar approach by expressing the urgency for climate scientists to pay close attention to scales of real human activity and ecosystem services e.g. headstreams, watersheds, and flow characteristics (Ivanov et al. 2012). Climate modelling is often conducted at coarse scales, while that span hundreds to thousands of kilometres at the detriment of community or livelihood levels.

A number of multidisciplinary scholars have continued to recognise the importance of multiscalar approach because of its ability to transcend many issues related to climate change vulnerability and risks in developing countries. For instance, considering the disproportionate reference to biophysical dimensions of climate change, Ghosal (2016) examined the crosscutting relations of geographic, political, socio-economic dimensions of vulnerability. Socio-economic issues in particular may fit into what Lovell et al. (2002) categorised as belonging to institutional scale where issues such as actors, jurisdiction, informal networks, indigenous knowledge, and governance come to the limelight. In other words, ignoring multiscalar dimensions can impede and undermine efforts to effectively address regional environmental sustainability (Morrison 2007). Again, the role of

[1]What is Climate Change Communication? See: http://climatecommunication.yale.edu/about/what-is-climate-change-communication/.

interpersonal influences also suggests the critical role of individuals who communicate climate change through community network and influences (Leombruni 2015) and eventually that influences government policy.

The greatest impediment to climate change science may come through misinformation and misrepresentation that may arise from poor communication of narratives associated with the notion of climate change. Such skewed communication may affect how households, communities, corporate bodies, policy and decision makers receive knowledge about climate change related issues. All these actors need to know how climate change affect their future and how any measure taken to tackle climate change may also positively or adversely affect the future of their stake. For some time now, the knowledge brokers are increasing recognised as persons and or organizations that struggle to create and share knowledge and are able to help their audience to know-how, know-why, and know-who, said what in science (Meyer 2010). As per climate change communication to the public, a study by O'Neill and Nicholson-Cole (2009) revealed that using tone of narratives of climate change alarmism is counterproductive. As such, inclusive and innovative tools are essential for effective climate change communication.

In spite of the alarmists of climate change, the situation of many African communities is pathetic as far as climate change is concerned. In effect, given the myriad of the challenges that climate change poses in Africa, the complexity of the problems can only be appreciated deeply through multiscalar prisms. For instance, from development perspective, it is reported that climate change could hinder the attainment of the Sustainable Development Goals (SDGs) and could also reduce by 12% Sub-Saharan Africa's Human Development Index (Chirambo 2016). Another critical dimension of climate change crises in Africa is food insecurity. A recent study reveals that adaptation mechanisms being taken to improve adaptation of staple crops (e.g. sorghum: *Sorghum bicolor Moench*) to future climate change is not promising as their production would only be marginal (Guan et al. 2017). Such decline in agricultural productivity resulting from climate change would affect the income levels of smallholder farmers and other repercussions include increased vulnerability to diseases and education in drylands (Amjath-Babu et al. 2016).

Considering the increasing population and energy demand and also Africa's potentials in generating renewable energy, studies have indicated that climate change undermines realisation of Africa's potential solar and wind energy options (Fant et al. 2016). Even as more people inhabit urban centres in Africa and the number keeps growing with increasing migration, only cities in South Africa appear on the global map of cities with defined adaptation strategies (Araos et al. 2016). Going in tandem with this chapter's arguments on multi-scale dimensions of climate change, Lyle (2015) pointed out that climate change adaptation ought to consider cross-scale interactions and hierarchical problems of the climate change crises. In other words, using positive images and narratives is the most engaging tool. Nevertheless, scientists have continued to publish alarming study findings, the media spills negative news about human future in the era of changing climate, while environmentalists confront corporate bodies. Several rounds of climate talks have witnessed frustrations and deadlocked meetings. Climate change issues are

communicated to the audience from business, policy, communities, universities and research centres who interpret them according to their concerns. Hence it is possible that narratives emerging from such meetings create confusion and frustration. In writing this chapter, the authors were motivated by the recent arguments made by Mortimore (2016) who raised the issue of changing paradigm in managing crisis of desertification in the Sahel region. The highlighted the nature of gaps between communities, policymakers and international development organisations.

2 Justifications and Options for Delivering Climate Change Communication Narratives in the Drylands of Sub-Saharan Africa

The Sahel region is about the most infamous region in Africa for its droughts and climate stressed human casualties and sufferings. The United Nations Environment Programme (UNEP 2011) dubbed the Sahel region as a ground zero to mark it as a dryland area with severe levels of starvation particularly during drought cycles. This situation of the area usually makes it attract the attention of the international media, science, development and humanitarian communities. Another critical issue that makes the area very known in the cycle of climate change and human impact research groups is the accelerated drying up of the Lake Chad. Situated between Latitude 13° 0′ 0″ (13.0000) and Longitude 14° 10′ 0″ (14.1667), the Lake Chad is Africa's fourth largest lake.[2] The lake's waters and marshes have desiccated progressively to the extent that its areal coverage of about 25,000 km^2 has shrunk to less than 2500 km^2 which is less than 10% of its size in 1960 (Lake Chad Basin Commission 2016). Many scholars have attributed this to droughts and other upstream land use activities in the basin. As such, the recurrent droughts, and desiccation of the Lake Chad and its tributaries are seen as driving forces behind food insecurity, rising conflicts and insurgencies in the area.

3 Narratives on Climate Change in the Sahel

The Sahel is a strip of dryland that extends from Senegal in the West though the Horn of Africa and it forms a major transitional land between Sahara desert and Savannah region. The Sahel region receives little rainfall and experiences minor and major droughts within every five years (Kandji et al. 2006). In connection to that, Ching (2010) predicts that yields from rain-fed agriculture could fall by 50

[2]Lake Profile—http://www.worldlakes.org/lakedetails.asp?lakeid=8357.

percent by 2020 in Africa; and livestock production would plunge due to rangeland degradation. These drought cycles undermine food security, which in turn affects livelihoods in the West African Sahel (Mortimore and Adam 1999; Wittig et al. 2007; Mortimore et al. 2009; Mortimore 2010). This makes vast groups of agriculture dependent people vulnerable. The 20th century had several bouts of intense droughts: 1898–1916, 1930–31, 1940–41, 1947–49 through those of 1968–1988 which recorded minimal rainfall in 1971, 1973, 1981, 1982 and 1987 (Jacques and Le Treut 2006). For some researchers, the 1983–1985 droughts were the worst in terms of population drift to cities (Wilson and Legesse 2004). Neo-Malthusians surmise that some Sahelian states are "demographically entrapped" as their population has exceeded their physical carrying capacity (King and Wang 2007). Such countries struggle to cope with droughts and desertification, but trends in climate variability now make them to battle with floods too (Dembowski 2007). In the same fashion, conflicts over control of natural resources are part of African drylands risks (Osman-Elasha 2007). Consequently, the future of African Sahel is apocalyptic due to combined impacts of up-surging climate change events on the quality of human life (Ehrhart et al. 2009).

Some scholars view what is happening in the Sahel as climate change and climate variability. According to, Mouhamed et al. (2013) warming trend throughout the region was observed from 1960 to 2010, and this was noticed through negative trend in the increasing number of cool nights, warm days and warm spells. Rainfall trends have shown the nature of changes as shown in Table 1.

The decades long climatic data variability shown in Table 1 lends credit to some previous studies that single out rainfall and also wind as main features of changing climate and the Sahel and at the same time attributed poor livestock health and reduced crop yield to climatic change and variability (Mertz et al. 2009). In other words, it is crucial to communicate the story of the Sahel through different prism and perspectives.

More recently some studies suggested that drought tolerant native and exotic tree cover lost 1968–1984 were recovered particularly around residential areas (Hänke et al. 2016). These kinds of positive narratives are rarely discussed and communicated to communities and policymakers. The findings underscore the critical role of land use change in environmental change in African drylands. Nonetheless, this does not mean droughts do not have negative effects on the Sahel vegetation at all. Drought occurrence has affected species distribution which is shown to reduce remarkably after drought incidents in the region (Hiernaux et al. 2006; Spiekermann et al. 2015). Tuareg people are closely associated with social and environmental conditions explained above. They are minority ethnic group with population of three million in the Sahel and Sahara states have been involved in crises in Niger and Mali that trigger migration (African commission on human and people's rights —ACHPR 2005).

Table 1 Rainfall trends 1960s to 2010 as collected from different synoptic stations across the Sahel

Indices	Nouakchott		Bamako		Ouagadougou		Niamey		N'Djamena		Units
Periods	1961–1990	1991–2010	1961–1990	1991–2010	1961–1990	1991–2010	1961–1990	1991–2010	1961–1990	1991–2010	
Max 5-day rainfall	33.7	44.7	123	117	104	109	86	97	88	103	mm
Extremely wet day total rainfall	5.7	18.6	48.1	62.7	44.4	45.6	30.9	37.8	29.3	45.7	mm
Annual total rainfall	84.6	95.5	913	943	782	724	535	541	505	583	mm
Max consecutive wet days	2.1	1.5	5.0	5.4	5.1	4.6	3.8	3.8	4.2	3.7	day

Adapted from: Mouhamed et al. (2013)

4 History of Climate Change Science and Climate Change Negotiations

Circumstances of regions such as the Sahel provide cogent reasons on the urgent need to explore more scientific and policy options to deal with the challenge of climate change. It took many years of blame shifts before countries and institutions agree on the need to go for negotiations on climate change. Negotiations are part of the science, policy, development and diplomacy narratives and response to climate change. However, the dividing line between them is slim because they are often intertwined and closely related. For instance, greenhouse gas mitigation and climate change adaptation are two critical terms that always bring science and policy community to dialogue (Schipper 2006). According to Hulme (2009) the history of modern climate change dates back to 19th May 1859 when John Tyndall an Irish scientist working with the Royal Institute in London discovered the absorptive capacities of gases and vapours when exposed to atmospheric radiation. This discovery followed the ideas put forward by French Scientist namely Joseph Fourier 30 years before Tyndall findings. Following Le Treut et al. (2007) we here extract the most important climate science related activities over time as illustrated in Table 2.

Based on the information in Table 2, the world has witnessed tremendous scientific contributions in the field of climate science and data collection. Thus, there is massive improvement in knowledge and data collection which is sufficient and reliable enough to establish patterns of climate change. However, since scientific findings

Table 2 Climate science in a timeline extracted by authors from Le Treut et al. (2007)

S/N	Period	Climate science in a timeline
1	1600	Invention of thermometer
2	1653	Establishment of first meteorological network in northern Italy
3	1853	Commencement of metrological observations from ships
4	1873	Establishment of International Meteorological Organization (IMO)
5	1873–1881	Köppen's contributions to enhancing climatic data quality and statistics
6	1923	Commencement of World Weather Report
7	1938a	First global temperature time series related to CO_2 produced
8	1938b	First measurement of urban heat island
9	1950	Production of world temperature time series 1950–1845
10	1969	Production of first maps of monthly temperature anomalies
11	1970s	Spatial interpolation and weather stations averaging techniques introduced
12	1982	Integration of global satellite data into mainstream observations
13	1990s	Massive automation of weather data collection points
14	2000s	There over 400 million individual readings of thermometers at land stations and over 140 million individual in situ sea surface temperature observations

are by their very nature not incontestable. At the same time, scientists lack the power to make decisions on how to deal with climate change and its impacts. As such, practical solutions to climate change have become a Holy Grail that is constantly being sought by politicians, scientists, communities and intergovernmental institutions. It is common knowledge that scientists have been exploring the impacts of anthropogenic activities on the climate and it only recently that such knowledge is communicated to policymakers who often get summary for policy makers (SPMs). At the moment the culture of summary for communities is largely uncommon.

The major breakthrough and bridge between science and policy communities with regard to climate change is the establishment of the United Nations Framework on Climate Change (UNFCC). The establishment of this body seems to be one of the main achievements of the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil. Since that remarkable achievement, the grounds for climate change negotiations were opened and several rounds of talks were held across different cities and continents. A summary of the various climate change Conference of Parties meetings is outlined in Table 3.

With some 195 parties, the UNFCCC is the largest political response to climate change.[3] Based on the Table 3, it is obvious that the COPs have virtually gone round all the global regions. However, the important question relevant to this analysis is why it has been difficult for the parties to arrive at all-encompassing, inclusive, legal, and responsibly binding agreements on how to avoid the global warming. COPs are avenue where scientists, policymakers, activists and many other stakeholders meet. Hence, the kind of messages, notes, and agreements being communicated paly critical role in shaping the success and future of such agreements.

Although the importance of climate change communication is highlighted in the above paragraphs, it is obvious that the crucial strategies are not being exploited appropriately in African countries. Even in developed countries, its advantages are not yet be fully developed and implemented to the benefit of mainstreaming climate change debate in policy, business, science, and community cycles.

5 An Overview of Climate Change Communication Strategies

According to Jeffery Sachs—one of the leading scholars on climate change science and policy, "the public must be able to interpret and respond to often bewildering scientific, technological, and economic information" which allows them to "take the pivotal actions needed to respond with urgency and accuracy"[4] to the challenges of

[3]COP—What's it all about? http://www.cop21paris.org/about/cop21.

[4]In: introduction to The Psychology of Climate Change Communication a Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public. CRED, New York.

Table 3 COP timeline from 1992 to 2016 complied relevant websites[a]

S/N	Time	Conference of parties	Held in
1	9th May, 1992	UNFCCC adopted	New York, United State
2	21 March 1994	UNFCC ratified	
3	28 March–7 April 1995	COP 1	Berlin, Germany
4	8–19 July 1996	COP 2	Geneva, Switzerland
5	1–10 December 1997	COP 3	Kyoto, Japan
6	2–13 November 1998	COP 4	Buenos Aires
7	25 October–5 November 1999	COP 5	Bonn, Germany
8	November 13–24, 2000	COP 6	The Hague, Netherlands
9	October 29–November 9, 2001	COP 7	Marrakech, Morocco
10	October 23–November 1, 2002	COP 8	New Delhi, India
11	December 1–12, 2003	COP 9	Milan, Italy
12	December 6–17, 2004	COP 10	Buenos Aires, Argentina
13	November 28–December 10, 2005	COP 11	Montreal, Canada
14	November 6–17, 2006	COP 12	Nairobi, Kenya
15	December 3–15, 2007	COP 13	Bali, Indonesia
16	December 1–12, 2008	COP 14	Poznan, Poland
17	December 7–18, 2009	COP 15	Copenhagen, Denmark
18	November 29–December 10, 2010	COP 16	Cancún, Mexico
19	November 28–December 9, 2011	COP 17	Durban, South Africa
20	November 26–December 7, 2012	COP 18	Doha, Qatar
21	November 11–23, 2013	COP 19	Warsaw, Poland
22	December 1–12, 2014	COP 20	Lima, Peru
23	November 30–December 12, 2015	COP 21	Paris, France
24	November 7–18, 2016	COP 22	Marrakech, Morocco

[a]Environmental and Energy Study Institute (http://www.eesi.org/policy/international); Centre for Climate and Energy Solutions (http://www.c2es.org/international/history-international-negotiations)

climate change. On the other hand, Corner et al. (2015) identified 12 tools for communicating climate change knowledge and outreach. These include the following:

- Manage your audience's expectation
- Start with what you know, not what you do not know
- Be clear about the scientific consensus
- Shift from uncertainty to risk
- Be clear about the type of risk you are talking about

- Understand what is driving people's views,
- The most important question is 'when' not 'if'
- Communicate through images and stories
- Highlight the positives of uncertainty
- Communicate effectively about climate impacts
- Have a conversation, not argument
- Tell a human story

Climate science communication has had some staggering movements even in developed countries. For instance, a study by Pew Research Center (2009) revealed that public perception of climate change in the US is at the bottom list of American priorities. However, a more recent study shows that perception of climate change generally varies with age of citizens in a country. In the US, a study shows that 89% of the millennials (persons born in 2000 and after) believed that climate change is human induced and is happening and no age group has as much perception as this young persons (Akerlof et al. 2016). In general, there is a positive change in respect of climate change perceptions in the US where 70% of the population believe climate change is happening and 67 said they feel concerned about climate change and global warming (Leiserowitz et al. 2016).

Communication is core to effectiveness of the goals of scientists and practitioners. For instance, in healthcare delivery system it is found that communication helps in supporting patients' self-management, adherence, satisfaction, and it enhances patient-physician relationship, supports management of emotions and decision-making (Ang et al. 2014; Zill et al. 2014). As per climate change, media is expected to play critical role in informing the public about the connection between climate change science and extreme weather events such as frequent flooding. However, some critical scholars are of the view that the media reportage on extreme weather event has not satisfactorily been able to engage the science of climate change (Gavin et al. 2009). In the west, documentaries are used as important outlets for engaging the public. A number of award-winning documentary films on climate change have been produced and probably enjoyed millions of views. Some of the popular documentary films are outlined in Table 4.

Besides documentary films production, one of the yielding strategies for whetting the public interest is through production of eco-fiction works. These are mostly prose works that focus on narratives that have ample consideration for environmental issues. At the height of climate change campaigns, a number of authors have written novels that narrate climate change through their characters and scenes. Table 5 outlines examples of the leading books on climate change.

The age of the Internet has also revolutionised how climate science and policy are communicated to the public. One of the most recent and effective internet climate knowledge dissemination tools is through massive online open courses (MOOCs). These are Internet based free courses organised by academic and research institution to offer introductory knowledge on topical issues such as climate change. Examples of some climate change related MOOCs are given in Table 6.

Table 4 Some of the leading documentary films on climate change

S/N	Year of production	Title of documentary film	Message
1	2006	An Inconvenient Truth	To raise public awareness on the dangers of global warming
2	2006	The Great Warming	Demonstrating effect so of climate change on communities
3	2007	The 11th Hour	Urgent call to respond to climate change
4	2009	Tapped	Dubius practices against the environment
5	2009	The Age of Stupid	Futuristic view on climate change
6	2010	Trading on Thin Air	Role of big businesses
7	2011	The Island President	Role of political leaders
8	2012	Chasing Ice	Melting of ice
9	2012	Revolution	Role of people in dealing with climate change
10	2012	Inconsistent Truth	Opposition to climate change science
11	2013	The Human Experiment	People's exposure to chemicals
12	2013	More Than Honey	The importance of bees in ecosystem and their vulnerability to eco-change
13	2014	Merchants of Doubt	Scepticism on climate change
14	2014	Cowspiracy: The Sustainability Secret	Cattle and the environment
15	2016	Gasland	Complexity of environmental change

In most cases, reputable scholars run the courses for a few weeks usually 2–8 weeks. Participants log into their websites at will to watch lecture videos, read materials and do assignments. Sometimes, certificates are offered to willing individuals at some cost.

It is obvious that most of the climate change communication strategies explained above are based on examples from Europe, US and other parts of the developed countries.

In general, it appears that individuals, universities, research institutions, civil societies and public institutions have played important role in disseminating knowledge on climate change science and policy. It is most probably, that this sustained efforts and innovations are responsible for the tremendous breakthrough achieved in the field of climate change communication which has significantly improved the level of public opinion in issues relating to climate change at least in big countries such as the United States. Nevertheless, we have also seen efforts by groups to use some of the strategies to refute or cast doubts on the integrity of climate change science and policy. It is important to note that, the paucity and or poor visibility of climate communication strategies for developing countries such as those in the sub-Saharan Africa region does not mean such knowledge and strategies are absent. The options and justifications for emphasising on the need for

Table 5 Some of the novels loaded with climate change issues

S/N	Year of publishing	Title of novel	Author
1	2012	Memory of Water	Emmi Itäranta
2	2012	Flight Behavior	Barbara Kingsolver
3	2012	A Being Darkly Wise	John Atcheson
4	2013	Odds Against Tomorrow	Nathaniel Rich
5	2014	The Bone Clocks	David Mitchell
6	2015	Nature's Confession	J. L. Morin
7	2011	The Twig Stories series	Jo Marshall
8	1987	The Sea and The Summer	George Turner
9	2015	Shackleton's Man Goes South	Tony White
10	2014	Climate Changed: A Personal Journey Through Science	Philippe Squarzoni
11	2013	Back to the Garden	Clara Hume
12	2016	Hot Season	Susan DeFreitas
13	2016	The Humanity Bureau	Dave Schultz
14	2016	Tree Volution	Tara Campbell
15	2016	Flip the Bird	Kym Brunner

climate change communication strategies in African drylands are discussed in the next section.

The stakeholders in the Sahel need to urgently embrace innovative strategies to foster mitigation and adaptation strategies. Against this backdrop, the narratives needed in this context are those that are multi-scalar in nature and climate change communication should be one of the most needed interventions.

In the case of the Sahel, Toulmin and Brock (2016) argued that after many years of failed narratives in the drylands, it is imperative to develop new narratives that fuse scientific and indigenous people of the Sahel. Indeed, one of the key challenges is the continued fragmentation of science and policy framings in the region. According to Mortimore (2016), governments and external (global) players and local scientists use different narratives in explaining the climate change. This fragmented, and incoherent posture of science and policy is a pointer to the lack of people focussed and holistic measures for dealing with crises in the Sahel. The crucial point here is that there is a wide gap in knowledge sharing and integration into policymaking. Again, it is understandable that there is problem in the use of narratives. For instance, international institutions and intergovernmental agencies feed national government with narratives that are not necessarily reflective of local knowledge and experiences. Hence, there are gaps and fragmentation in the way knowledge is communicated from all angles and this has always affected the effectiveness of intervention strategies in the Sahel.

Table 6 A selection of climate change MOOCS

S/N	Title of the MOOC	Organised by
1	Agriculture and the World We Live In	Massey University
2	Our Energy Future	University of California, San Diego
3	Global Warming II:	The University of Chicago
4	Our Earth's Future	American of Natural Museum of History
5	How to Change the World	Wesleyan University
6	Our Earth: Its Climate, History, and Processes	University of Manchester
7	Deception Detox	Erasmus University Rotterdam
8	Climate Justice: Lessons from the Global South	UNESCO/FUTURELEARN
9	Traitement médiatique du changement climatique	Université de Versailles SQ-Yvelines
10	Climate Change Leadership	Uppsala University/FUTURELEARN
11	Our changing climate: past, present and future	University of Reading/ FUTURELEARN
12	Climate Change: The Science	The University of British Columbia
13	Making Sense of Climate Science Denial	University of Queensland
14	Causes of Climate Change	University of Bergen
15	Monitoring Climate from Space	European Space Agency

Indeed, more and more researchers are shifting attention to resilience rather than desertification, this is because as Benjaminsen (2016) pointed out, desertification is a vague concept and what matters is to understand the dynamics between rainfall changes and the coping strategies of the people of Sahel. It is interesting to note that while desertification is a questionable concept, the increasing concern among the critical Sahel scholar is on the changing patterns of rainfall which is associated with global warming. As such, it becomes important to develop a framework that identifies the multiple scales and typologies of climate change communication needed in the Sahel. Any framework for climate communication for the Sahel should be able to integrate indigenous knowledge, findings of local scientific community as well as local and global policy response strategies to climate change in drylands. This is even as one is not oblivious of the dismal situation of climate collation and management in Africa. Climate data quality is important for all narratives that come out of the Sahel. It is worrying that the distribution ratio of weather stations in Africa is one per 26,000 km^2 or eight times lower than the world average (Algamal 2011). With such a huge deficit in real-time ground data, regional and local climate modelling cannot be overwhelmingly satisfactory.

However, it is pertinent to note that the most neglected aspects of climate change knowledge in Africa is indigenous knowledge about climate change and local adaptation strategies. African societies have used traditional environmental knowledge and environmental ethics which is often communicated to future

generations through oral narratives. In the modern age some of these environmental and climate related knowledge systems have been documented and mainstreamed into the global environmental knowledge systems (see Barau 2009 and Barau et al. 2016). One of the most widely read works of literature in Africa is Chinua Achebe's *Things Fall Apart*. This multiple award winning prose narrates some stories that tell a reader how Africans perceive climatic variability and particularly in relation to changing patterns of rainfall and how that affects livelihoods in the society. Although the half century old work was not conceived as an eco-fiction, it can be used as example of works that demonstrate some aspects of traditional climate change knowledge climate change. Thus, it can be used in communicating climate change knowledge for African society. Some of the relevant passages and sentences from *Things Fall Apart* are given below.

- *When they had eaten they talked about many things: about the heavy rains which were drowning the yams…* (Chap. 1, p. 5)
- *The first rains were late, and, when they came, lasted only a brief moment. The blazing sun returned, more fierce than it had ever been known, and scorched all the green that had appeared with the rains. The earth burnt like hot coals and roasted all the yams that had been sown… He had sown four hundred seeds when the rains dried up and the heat returned. He watched the sky all day for signs of rain clouds and lay awake all night.* (Chap. 3, p. 16–17)
- *But the year had gone mad. Rain fell as it had never fallen before. For days and nights together it poured down in violent torrents, and washed away the yam heaps. Trees were uprooted and deep gorges appeared everywhere. The spell of sunshine which always came in the middle of the wet season did not appear. The yams put on luxuriant green leaves, but every farmer knew that without sunshine the tubers would not grow.* (Chap. 3, p. 17)
- *All the grass had long been scorched brown, and the sand felt like live coals to the feet. Evergreen trees wore dusty coat of brown. The birds were silenced in the forests, and the world lay panting under the live vibrating heat. And then came the clap of thunder. It was angry, metallic and thirsty clap, unlike the deep liquid rumbling of the rainy season.* (Chap. 14, p. 91–92)

Besides creative works, there are certain scientific works on the drylands which included traditional environment knowledge and experiences of local communities on climate related knowledge and environmental management skills. For example, using information from field based personal communication with some respondents in the peri-urban Kano, Maconachie (2014) reported on the complicated relations between land use management, biodiversity and climate as quoted below:

> The *Kuka* is excellent because it doesn't have too many leaves. But the *Tsamiya* has very broad leaves and it will make too much shade on the plot, so it is not as good for the crops. The *Gawo* tree produces fruits that animals love. So under the *Gawo*, you will see lots of animals, and they will drop their *taki* and make the soil rich. When you see the *Marke* tree, you know the land is not rich. The land around this tree becomes very hot and dry, even in the rainy season.

This shows that the science community has recognised the importance of local knowledge. Perhaps, lack of its integration or communicating such knowledge into the mainstream policymaking and climate change debates at national, regional and global scales undermines its relevance. Interestingly, in some instances, the science community has also recognised local people's skills and knowledge on climate and crop dynamics in the drylands (see Ahmed 1998, p. 150) as given below:

> [O]n August, 28th 1996 the crops were stressed and farmers visited mosque to pray for rains … luckily it rained the next day for about an hour. The highest soil moisture increase at depth of was 5 cm was recorded at sites. The farmers explained that this is bad for crops because the higher moisture level at 5 cm would trap heat … this raises soil temperature and adversely affects plant growth. The farmers describe this as soil fever (*zazzabi* in Hausa).

6 Proposed Climate Change Communication Framework for the Sahel

In view of the immense challenges of climate change stress in the Sahel, it has become necessary to explore the potentials inherent in the indigenous knowledge, existing body of literature on climate change in order to develop an integrated framework that allows direct exchange and sharing of information. For climate change communication to be effective it is imperative to share information and knowledge between local, regional and global institutions such as the UNCCD, national and local governments, local scientists, international dryland scholars, and local livelihood groups such as farmers, pastoralists fishermen and women groups. Our proposed framework is interdisciplinary, cross-institutional, and cross-cultural in nature. As indicated graphically in Fig. 1, there are 18 variables that are essential for achieving effective climate change communication in the African drylands.

The selection of these variables was based on experiences as well as opportunities and lessons learnt from developed countries. In addition to that, the region's existing fragmented approach in climate change science, policy also warranted the identification of these variables. Climate change communication strategies ought to be integrated with local knowledge on climate, findings of climate research and climate science and policy. Our proposed framework is not absolutely different from what obtains in other places. Nevertheless, it prioritises some issues under each of the four components of the framework. For instance, one of the things that is identified as very important is the role local languages in communicating climate change science and policy. For any form of knowledge or innovation on climate change mitigation and adaptation, it has to be communicated in local, languages. Again, considering the rapid proliferation of social media in both urban and rural areas, it is crucial to disseminate climate change knowledge through such platforms

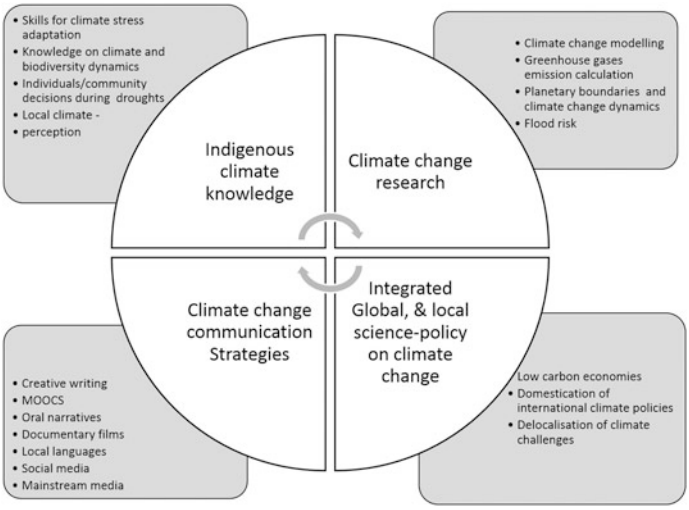

Fig. 1 An integrated climate change communication for African dryland

in local languages. This will go a long way in creating avenues where narratives from all stakeholders will build bridges of knowledge.

7 Conclusion

This chapter has been able to identify the situation of the Sahel region in the context of the public access to climate change information. It has shown that climate change science and policy is largely within access and consumption of scientists, policymakers and development organisations. Even within the ranks of these stakeholders climate change knowledge and policy remains fragmented and excludes critical stakeholders such as farmers and pastoralists who own priceless ecological knowledge and experiences that can be integrated into climate change communication for African drylands. What comes clearly out of this chapter is the fact that the changing climate has exposed African drylands and their people to hardships and fast degrading quality of life and livelihoods. It has also explored the potentials of educating, involving and disseminating state of the art knowledge of climate change communication to local people, policymakers and scientists in the most cost effective, multiscalar and interdisciplinary manner. For decades, the African drylands have seen local and foreign interventions that basically do three things. One is deployment of scholars who try to understand the dynamics of the environment-people relationship in a world of changing climate. Secondly, humanitarian assistance has become a defining feature of the region. Such

interventions aim at dealing with hunger and malnutrition that usually come with drought incidence. Thirdly, development assistance for countries in the dryland also used as a means of helping governments and NGOs to combat poverty, illiteracy and other underdevelopment challenges associated with the dryland.

Against the backdrop of the missing links between all the three forms of interventions, this chapter has identified the critical need for all the stakeholders in the region to embrace climate change communication as a bridge across divides that have traditionally disconnected local communities, scientists, policymakers and local and global stakeholders. This chapter puhe public through innovative tools such as MOOCs. In spite of the promising features of this integrated approach, this work is limited by the fact that the model it has proposed in Fig. 1 has not been empirically tested. Similarly, the paper has not identified the gaps between the means of disseminating local knowledge systems in Africa and contemporary science and media supported communication strategies practiced with some level of success in some of the developed countries. Nevertheless, by using this approach, it will immensely help in supporting informed decision on what works best for people, institutions and the environment. It is hoped that the modest contributions of this chapter will jump-start interdisciplinary studies and projects between universities and media and communication practitioners to design models of climate change communication for African drylands.

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Assessing High School Student Perceptions and Comprehension of Climate Change

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1 Introduction

Goal thirteen from the *Transforming our world: the 2030 Agenda for Sustainable Development* states that we must "take urgent action to combat Climate Change and its impacts" (UN 2015). Climate Change (CC) and Global Warming (GW) is also one of the five priority areas of the Strategy 2020 of the European Commission and it constitutes a major global challenge needing local responses. CC understanding entails identifying mutually influential relationships between Nature, Society, Culture, Education and Science. Any intervention, either to mitigate or/and adapt to CC, necessarily involves the full complexity of its environmental, sociocultural, educational and science dimensions. The ways CC is viewed and addressed in a given country also depends on its cultural, political, and scientific backgrounds and,

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to a large extent, on the specific aspects of the changing climate in that country and on its actual and perceived future impacts (Carvalho et al. 2014; Viegas et al. 2014).

Today's generation of students belong to the "*climate change generation*" that grew up with more information and less scientific uncertainty about CC and GW. CC and GW is a matter of global concern, being a significant challenge facing society today and becoming a central issue to society (Leal Filho et al. 2014), and educational institutions and agents (teachers, students, other pedagogical agents from formal and informal education) need to engage and be active in the search for regional and local solutions for what is a global problem (Leal Filho 2010). However it is not always clear the correlation between levels of knowledge and behavioural change to address CC, and there is indication that behavioral engagement can occur in the absence of a complete understanding of the problem (e.g. Ortega-Egea et al. 2014; Rhodes et al. 2014). Studies conducted in Portugal (e.g. Carvalho et al. 2014; Santos et al. 2016) suggest that there is significant lack of information and that this may be impacting the ways they relate to CC.

Several studies on elementary and secondary school students' concern and knowledge about climate change (Anderson and Wallin 2000; Boyes and Stanisstreet 1992, 1993; Boon and Cook 2009; Daniel et al. 2004; Francis et al. 1993; Gowda et al. 1997; Rye et al. 1997; Shepardson et al. 2009, 2011) were conducted in recent years beginning with Boyes and Stanisstreet (1992, 1993) on British elementary students' perceptions of the causes and consequences of the "greenhouse" effect. Overall such studies stated that students held many significant misconceptions about the greenhouse effect and its relationship to climate disruption. Studies on Environmental Literacy from the Portuguese high schools national system revealed a same pattern both in students (Cordeiro et al. 2013; Gomes et al. 2014; Almeida et al. 2014) as well as in teachers (Câmara et al. 2014; Esteves et al. 2014; Marques et al. 2014).

The purpose of this study was to investigate High School (HS) students' perceptions of CC/global warming (GW). This work is the first one conducted within Portuguese HS students and the results in this context should have meaningful implications for national CC policies in the future (Jamelske et al. 2013) as well as HS Curriculum Differentiation and Education Adjustment Plans to the students' perceptions. As any other social-environmental issue, perceptions and expectations of CC, as well as knowledge on the topic, are important in the actions taken relating to this multidimensional subject. Hence, it is important that students acknowledge that anthropogenic actions are a main cause of CC (which the majority of our student's sample did), but also that humans are a key factor in mitigating CC, or by the fact that the main responsibility for CC mitigation is seen as falling upon governments and institutions, rather than in individuals (Santos et al. 2016).

2 Research Methodology

Research was conducted at a high school in Central Portugal (District of Aveiro). The survey was applied to all the high school students (n = 270) from the 10th to the 12th grade, enrolled in the areas of Sciences and Technology (Sci &Tech), Languages and Humanities (Lang & Human), Socio-economical Sciences (Socio-econ Sci) and Professionalization.

2.1 Questionnaire and Data Collection

The data were collected through a self-completion questionnaire consisting of 29 closed-ended questions and two open questions aiming at characterizing students from the socio-demographic, and from their perceptions, beliefs, motivations, attitudes, knowledge relating to the topic of CC. The questionnaire was adapted from Wachholz et al. (2012) and Manolas et al. (2010) and following studies by other authors (e.g. Leal Filho et al. 2014). This questionnaire was validated for HEI students by Santos et al. (2016). Google Drive was used to host the questionnaire and allow for the online survey. The questionnaire was pre-tested among undergraduate students not enrolled in the questionnaire application and the results of the pilot study were used to refine the questionnaire. Students took part in the survey willingly and the time required for filling in the questionnaire was ca. 10 min. Respondents were assured that their responses remain anonymous. The data was collected online, during face-to-face classes, under the supervision of the teacher, in the second week of November 2015.

2.2 Statistical Analysis

Data were downloaded into MS Excel and then exported to IBM SPSS Statistics for Windows, version 22®, for statistical analysis. Statistical exploratory univariate and bivariate analyses were performed on the data collected (frequencies, total and column percentages, adjusted residuals). Associations between categorical variables were tested through independence chi-square tests. Whenever 20% or more of the tables' cells presented expected counts below 5 or 2 × 2 tables were analyzed, independency between ordinal and/or categorical variables was assessed through Fisher Exact Tests. All statistical tests were two-tailed, with significance levels of 5%. Only statistically significant results were commented on the results section.

3 Findings

3.1 Respondents Characterisation

The questionnaire had a response rate of 100%. Respondents mostly belonged to the Sciences and Technology course (43%), followed by the Professionalization course (35%), and less to the Socio-economical Sciences (13%) and Languages and Humanities (9%). Gender distribution among the courses was different: most students in the Professionalization courses were male (73%), while they represented 50% in the Sciences and Technology, 38% in Social and Economics Science, and only 17% in the Languages and Humanities courses.

Students were mostly enrolled in the 10th or in the 12th grade (respectively 41 and 38%), and less on the 11th grade (21%). These students were 46% female and 54% male. The age groups reflected the distribution of students throughout the grades, i.e. 33% were aged between 14 and 15 years old, 45% between 16 and 17 years old, 11% were aged 18 years old, and 8% was above 18 years old.

3.2 Perceptions Relating to CC and Their Impacts

Nearly all respondents (76%) believed that CC was happening, while 20% believed that they might be happening, 3% "did not know" and 1 respondent believed "it was not happening". In what concerns their interest, recognition of the importance and level of concern with the topic of CC, these three aspects were only slightly differently perceived among the students. Most students responded that they were either "very much" (24–31%) or "a lot" (51–59%) interested/concerned/recognising the importance of the topic of CC, while fewer responded to "have little" (15–17%) or no interest/concern/recognition of importance of CC (less than 1%).

Also, the perception of the impacts of CC on biotic communities and human communities, either in one's country (Portugal) or abroad (as a whole) was sensed with different time scales, depending on the type of community and on the country. There was a generalised perception that biotic communities were already impacted by CC, particularly abroad (62 and 71%, respectively for biotic communities in Portugal and abroad). A considerable number of respondents also perceived that CC impacts were already felt in human communities abroad (60%), but less (43%) in Portuguese human communities. Still, a substantial number of respondents though CC impacts would be felt between 10 and 25 years from now (44, 31, 28 and 22%, respectively in human communities in Portugal and abroad, biotic communities in Portugal and abroad).

Students' gender influenced their perceptions of time scale of CC impact on both human and biotic communities as 66 and 77% (respectively) female respondents perceived CC impacts as "existing already" opposing to 56 and 66% (respectively) of male students.

In what relates to the students training path, irrespectively of the course in which they enrolled, there were no significant differences in their concern or perception of the importance of the CC topic. A slight difference appeared to exist in the Professionalization course students', 23% of which stated to perceive the topic of CC as having "little importance", versus 11, 13 and 6% in the Science and Technology, Languages and Humanities or Social and Economical Sciences (respectively; although differences were not statistically significant). Also, irrespectively of the training path/course, the perception of the CC impacts on both biotic and human communities was not significantly different (although there was a greater proportion of students in Science and Technology that sensed it in the more immediate future, opposing to students in the Professionalization course).

The majority of students (75%) expressed that "the scientific community assumed that CC was happening", less (10%) felt that "there was much disagreement amidst the scientists relating to the subject", or (12%) "felt not knowing enough to form an opinion". Still a minority (3%) expressed that "most scientists did not believe that CC were happening". In this issue, female students expressed more frequently than male students that "the scientific community assumed that CC was happening" (82 and 69%, respectively). On the same topic, male students responded more frequently than female that "there was much disagreement amidst the scientists relating to the subject" (15 and 5%, respectively).

In what concerns their training path, most students enrolled in the Science and Technology and in Languages and Human courses perceived that "the scientific community assumed that CC was happening" (respectively 83 and 92%) versus 59% of students in the Professionalization course. Also, in the latter course there was a relatively greater number of students stating that "there was much disagreement amidst the scientists" (19% in the Professionalization, vs. 8 and 0% in the Science and Technology or Languages and Humanities).

The majority of students (94%) also perceived that human activities were an important cause of CC (vs. 6% who expressed they were not). Again, on this topic, gender had a significantly different perception, the female respondents having a greater response rate than male respondents regarding human activities being an important cause of CC (98 and 90% respectively). When inquired if humans could mitigate the effect of CC, most respondents shared the opinion that they could mitigate effects of CC, although among these 46% expressed "it was not clear if they would do what was necessary to achieve it", and 35% thought that "people did not have the will to change their behaviour in order to achieve mitigation"; only 12% believed that "humans would manage successfully to mitigate the effect of CC". Lastly, 7% thought that humans could not mitigate CC. When considering the gender effect, the majority of female respondents considered that humans could mitigate the effect of CC, although "it was not clear if they would do what was necessary to achieve it" (52% vs. 40%, respectively female and male), while male respondents were more optimistic in what concerned the success in mitigating the effect of CC (17 and 6%, respectively for male and female).

3.3 Training and Knowledge of CC

Regarding their basic education (grades 5th to 9th) the majority of the students (70%) felt that their training had focused enough on the topic of CC, less (20%) felt that their training had been insufficiently focused on CC, and very few (3%) felt that they had too much training on the subject. Still, 7% had not attended enough classes to form an opinion. On what concerns their secondary education, 25% had not attended enough classes to form an opinion. The majority of the remaining 202 respondents, felt that their training had focused enough on the topic of CC (77%), while nearly one fifth of students felt it had been insufficiently focused (17%), and very few (6%) felt they had too much training on that subject. When inquired if they felt the need for more information on the topic of CC to form an opinion, 12% of the students expressed the need for a lot more, 48% for more information, 34% for a little more information; only 6% felt no need for further information on the subject.

Differences were found among students in enrolled in different courses. In the Professionalization course 20% of the students admitted needing much more information on the topic of CC, versus a minority in the Science and Technology or Languages and Humanities (7 and 4%, respectively). Also in the Professionalization course, 22% of the students admitted needing a little more information on the topic of CC against 44% in the Sciences and Technology who stated the same opinion (or 33% of Languages and Humanities, even though this difference was not statistically significant).

Furthermore, when inquired about their knowledge on the subject, most respondents (69%) felt they had a moderate technical knowledge about the topic of CC, while some perceived their knowledge as extended (13%), or minimum on the topic (14%). Students knowledge of how their behaviour influenced CC followed a similar pattern, most felling a moderate knowledge (59%), some perceiving it was extended (26%), and fewer feeling a minimum knowledge (12%) of how their behaviour influenced CC.

However, when asked about the effect of the ozone hole on CC, only 10% acknowledged that the ozone hole was not a main cause of CC. Most students, 81%, responded that it was a main cause of CC and 9% didn't know whether it was or not a cause of CC.

No significant differences were found, when considering the effect of gender or training path/enrolled course in their knowledge or perception of knowledge on CC.

In what concerns their ecological footprint, most students (65%) had not estimated it (76% vs. 55%, respectively female and male). For the students who declared having calculated their ecological footprint, 10% had done so on the scope of their training and a little less (8%) had calculated it as outside the scope of their training; still 17% did not know if they had calculated it. Interestingly, most students in the Science and Technology, Languages and Humanities or Socio-Economical Sciences courses (73, 88, 77%) and had not calculated their ecological footprint, in opposition to 45% in the Professionalization courses

(although not statistically significant), and 21% of the students in the latter courses had calculated it as part of their training (against 6, 4 and 0%, in the other courses).

Finally, in what concerns the perception of the importance of CC for their future professional carrier, 48% considered that this topic was "moderately important" and 29% considered it as "very important". From these, a greater proportion of students in the Professionalization courses, considered that CC was "very important" to their professional future (38%, in the Professionalization courses, vs. 24, 29, 20% in Sciences and Technology, Languages and Humanities and Socio Economical Sciences; although not statistically significant).

3.4 Governance and Actions to Mitigate CC

There was a large conviction that the main actions in mitigating CC effects should be taken by governments (50%), although a considerable number believed that actions should be the responsibility of individuals (33%), and a small number thought that the responsibility should lay upon corporations or NGOs (respectively 9 and 8%). Also, without an international agreement, e.g. Kyoto's protocol successor, most students, felt that there would be still a way to mitigate CC (60%), although many felt that such an international agreement was essential, or they "did not have an opinion on the matter" (respectively 20 and 19%). On this issue, female students were more optimistic than male students, answering more frequently that even without an international agreement there still would be a way to mitigate CC (70% vs. 52%, female and male).

Also most students from the Science and Technology (67%, although the difference was not statistically significant) and from Languages and Humanities (80%) believed that without an international agreement there still would be a way to mitigate CC, while only 45% of students in the Professionalization course shared the same opinion.

Regarding the behaviour of relational communities that surrounds each respondent, only 10% thought that most people in their relational communities acted to mitigate climate effects. Nearly half, 52%, perceived that most people in their relational community "took some actions to mitigate CC effects", and 30% perceived that they did not act in order to mitigate CC effects; 8% of the respondents did not know what was the behaviour of their relational communities.

As individuals, and globally, 74% had not taken actions to mitigate CC; among these 32% thought that the "actions of a single individual would not change anything". Only 26% of the respondents had taken some actions to mitigate the causes of CC. On this issue, female students answered more frequently than males that they had already taken some actions (16% vs. 8%, female and male), and less frequently that the action of a single individual would not change anything (27% vs. 36%, female and male). No differences were found in this issues among the students enrolled in different courses.

Finally, when inquired if they were to reduce their contribution to CC, most students felt that they would be increasing their life quality by a lot (43%) or a little (29%). Still, some felt that reducing their contribution to CC would not change their life quality (9%), or that it would decrease it by a little (12%) or a lot (7%). In this issue, female respondents answered more often than males that their contribution to mitigate CC would improve their life quality by a lot (47 and 40%, female and male), and responded less often that it wouldn't have any impacts on their life quality (3 and 14%, female and male).

As individuals, half respondents (51%) also expressed that they would support actions to reduce greenhouse gases including measures which implied e.g. paying more for fuel and electric energy, while a lesser number (35%) was not sure about it, and 14% would not support such actions. The mitigation actions taken by the respondents included reducing the use of private cars and fossil fuels and increasing "walking and cycling" (5%), increasing recycling and reutilization of materials (12%), reducing electricity consumption and water (18 and 10%).

4 Discussion

Comparing the present results with previous data obtained with Portuguese university students' (Santos et al. 2016) we see a lower comprehension of climate change issues in this younger aged group. The same trend is shown in high school students' interest, recognition of importance and level of concern with the topic of CC. Adolescence and related teacher displeasure, multiple interests or conceptual dispersion could explain part of this lesser perception of CC. A recent poll in the United States (Pew Research Center 2015) shows a clear relationship between age and views about climate change with scepticism growing with age. Comparing this research findings with the previous ones with University students (Santos et al. 2016) we do not confirm this pattern.

The low comprehension of climate change issues (scientific knowledge and assessment of climate change, mitigation and adaptation), societal challenges and perceived impacts in human systems and natural systems revealed by studies on students perceptions (Santos et al. 2016) is accompanied by levels of concern that contrast with limited understanding and rather weak behavioral dispositions to address climate change (Carvalho et al. 2014).

The perception of the impacts of CC on biotic communities and human communities, either in one's country (Portugal) or abroad (as a whole) was sensed with different time scales, depending on the type of community and on the country (the impacts of CC on biotic communities and human communities in one's country, are perceived as less impacted than abroad) and that impacts would be felt between 10 and 25 years from now (impacts are thought to appear latter in Portugal than abroad) should be explained by the searched information by high school students, the negative acceptance of thematic/environmental newspapers or audio-visual

media news by adolescents (Cordeiro et al. 2013; Gomes et al. 2014; Almeida et al. 2014), the school manuals with examples taken abroad (from extreme and more impacted geographies), and the reliance on youth magazines that are most times mere translations of Anglo-Saxon sources.

In the present study high school students' confidence in the scientific community was high (75%). On the other hand previous studies evaluating high school students environmental literacy (Cordeiro et al. 2013; Gomes et al. 2014; Almeida et al. 2014) and teachers environmental literacy (Câmara et al. 2014; Esteves et al. 2014; Marques et al. 2014) revealed low values of environmental literacy. The conjugation of this two findings make us assume that the scientific community/academia should conceptualize and structure a better interface with schools reaching high school students as well as teachers attracting them to science subjects. However the complexity of the debate among climate scientists (see Bryce and Day 2014) makes hard to communicate and teach about CC and GW at high school level. Despite the findings of climate scientists, the proportions of climate sceptics (for clarity in the concepts see Capsticka and Pidgeon (2014)) appear to be increasing in many countries (Tranter and Booth 2015). Stevenson et al. (2014) argue that we should overcome scepticism with education. We should overcome scepticism with better communication and education (intervening in Pedagogy, Curriculum, Teaching Practices, non-formal education, informal education and science divulging). Lutz et al. (2014) state that public investment in education in poor countries in the near future should be seen as a top priority for enhancing societies' adaptive capacity vis-à-vis future climate change.

A few studies (e.g. FAO 2007, Rohr 2008 and references herein) show that environmental changes impact men and women differently because of their gender roles and socio-cultural situation. Gender-differentiated roles and responsibilities in families and households, as well as gender-segregated labour markets and income gaps, cause differentiated vulnerabilities of women and men to the effects of climate change, not only in developing countries (Setti et al. 2016) but also in the European Union (Berlin Declaration 2007; European Institute for Gender Equality 2012) which explains gender differences regarding CC in our study. This findings mirror the ones of Wachholz et al. (2012) in the USA and the ones from Santos et al. (2016) in Portugal with women students demonstrating greater levels of concern.

Most students stated that in their scholar path they accessed to a large knowledge about climate change. Most students believe that CC is happening, that their main causes are anthropogenic, and they feel well informed on the topic of CC but when asked about particular concepts and processes of CC, their answers do not reflect their self-perceived knowledge. Similar results were obtained with our previous study with university students (Santos et al. 2016) and in other studies (e.g. the study of Löfstedt 1991), where the greenhouse effect was confused with the issue of ozone depletion), and other misconceptions can be found in the in other European (Manolas et al. 2010) and American (Wachholz et al. 2012 and references cited herein) university students. This type of inquiries usually reveals common misconceptions. Many pre-university students continue to identify that ozone depletion is a major factor driving climate change (Boon and Cook 2009) and that polluting less and recycling more is a way to mitigate CC, as presented in our study,

suggesting that this issues should be better addressed in the teaching curricula and at schools. Students' misconceptions of climate change (Manolas et al. 2010; Wachholz et al. 2012; Pascua and Chang 2015; Santos et al. 2016) also points to the need and urgency to intervene in Pedagogy, Curriculum, Teaching Practices, non-formal education, informal education and science divulging. Also Climate Change Education should be approached from an interdisciplinary and systems perspective (Mochizuki and Bryan 2015).

Our results also show that environmental thinking, consciousness, attitudes and behaviours are not always related, as also reported by Santos et al. (2016). However, as stated by Ortega-Egea et al. (2014), a profound shift in personal behaviour is needed to respond to the urgency of CC mitigation together with the need to actively engage future citizens as part of the solutions in their professional and private roles (Wachholz et al. 2012) starting in elementary schools and high schools. Thus, eventhough the inquired high school students pointed out to a greater role of individual action in mitigating CC, as compared to that of university students (Santos et al. 2016), they finalized by stating that for their future careers this issue is not so important (52%). This again shows the urgency for science quality and pedagogical actions in teaching about climate change, participation and citizenship, and climate governance (*Global Action Programme on ESD*; *transforming our world: the 2030 Agenda for Sustainable Development*; *European Institute for Gender Equality,* 2012). In the present study the inquired sample showed low levels of interest to be proactive in the solutions and mitigation measures to be taken to cope with solutions for this Global Change Global Problem. When asked about their actions to mitigate the causes of CC these were "short", both on the percentage that responded positively and on number of actions with effective contribution in CC mitigation. This result shows that environmental thinking, consciousness, attitudes and behaviours are not always related. As stated by Ortega-Egea et al. (2014) a profound shift in personal behaviour is needed to respond to the urgency of CC mitigation together with the need to actively engage future students (unrelated to graduation level) as part of the solutions in their future professional public and private careers (Wachholz et al. 2012).

In a context of increasing global inequality, global economic recession, conflict, and climate change is needed action in the advancement of climate science education in public schools (see for this purpose the exploratory research of Colston and Ivey 2015). A population's attitudes toward climate change can strongly influence governmental policies as well as community and individual climate-related behaviors (Leombruni 2015). Finally, as stated by Vaughther (2016), we should move beyond education systems that simply transmit knowledge to ones that promote graduates who are engaged in systemic change.

5 Conclusions

Discussions about the post-2015 education and development agenda in this context ambitiously seek to eradicate poverty, promote social and economic inclusion, tackle climate change, promote equity, and access to quality education (Sayed and Rashid 2015). This study confront us with the need for better high school climate change teaching and learning processes, quality and geographically contextualized information in science manuals, better trained/informed teachers (providing lifelong learning on climate change topics) and the need to overcome scepticism decreasing the barriers between universities teachers –academia, and researchers and high school spaces of learning. The students of today should be the environmental participative citizens of tomorrow and this study clearly shows that we still have a long but stimulating path to tread if we want to cope with the *2030 Agenda for Sustainable Development* (take urgent action to combat climate change and its impacts improving education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning) and the European Union *Horizon 2020 Societal challenge Climate action*.

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A Sustainability Livelihood Approach (SLA) Model for Assessing Disaster Preparedness and Resilience of the People: Case Study of Cox's Bazar Sadar Upazila in Bangladesh

Md. Mokhlesur Rahman and Weifeng Li

1 Introduction

Global climate is changing rapidly that affects environment, physical and biological issues significantly (Pulhin 2010). Volcanic eruption, solar radiation, extensive energy use and Greenhouse Gases (GHGs) emission from industries, vehicles, and buildings induce climate change (IPCC 2007, 2014). Consequently, high temperature, variation in rainfall, sea level rise, deforestation and desertification due to climate change are affecting animals and plants. Moreover, extreme weather events (e.g. floods, cyclones, typhoons, droughts) due to climate change are affecting people significantly (Pulhin et al. 2010; Shaw et al. 2010; IPCC 2014). It is observed that climate change is affecting global hydrological system, quality and quantity of water resources, disturbing freshwater and marine species by affecting habitation, seasonal variation, migration patterns, reducing crop yielding etc. (IPCC 2014). Some indirect consequences of climate change and disasters (e.g. poverty, food scarcity, health nuisance, ecological imbalance, loss of lives and properties) are also affecting society and livelihoods of the people (UNISDR 2007; Shaw et al. 2010). The current trend of GHGs emission will lead to further global warming, changing in all components of climate system and increasing adverse impacts on people and ecosystem (IPCC 2014). Therefore, a collective effort is necessary to challenge climate change and extreme events (e.g. agreement, policies, and plans).

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Bangladesh is a developing country with many socio-economic (e.g. poverty, low education) and environmental problems (e.g. disaster, pollutions). She is a low-laying riverine disaster prone and densely populated country. Additionally, climate change worsens devastation of disasters. Therefore, Bangladesh is recognized as one of the most vulnerable countries in the world. People in the coastal areas face the worst situation due to limited access to endowed resources, high risks and vulnerabilities to climate change and disasters (Ali 1999; Thomalla et al. 2005, ERD 2008). In contrast, coastal areas are endowed with enormous resources (e.g. mineral, fisheries, forestry, ports and tourism facilities). Nevertheless, excessive use, climate change and disasters destroy these resources, degrade environment and make people vulnerable to disaster. Low economic development, extreme poverty, geographic location and climate have made the country vulnerable to climate change and disasters. Moreover, poor socio-economic conditions, absence of emergency plan in development activities, inefficient institutional frameworks, and financial constraints increase the consequences (Pulhin et al. 2010).

Disaster preparedness is inadequate to mitigate risks in Bangladesh due to lack of proper institutional framework to enact policies related to climate change and disaster management. Regular review of the policies, ensuring local level participation and adopting indigenous methods can reduce disaster risks. Moreover, easy and quick ways of information dissemination and early warning system to inform people regarding imminent disasters allow people to prepare for the situation. Optimum utilization of available resources through systematic planning process is necessary to strengthen socio-economic condition of the people and adopt necessary risks mitigation measures. For example, Training program, awareness raising campaign can educate people about climate change mitigation and adaptation and disaster risk reduction strategies.

2 Literature Review: Assessing Community Resilience

Resilience indicates the capability of people to face adverse events (e.g. climate change, disaster) and recover from the undesirable situation to its normal state. Resilience to climate change and disaster increases with the increase of available resources, proper institutional framework, external supports from government and NGOs. The key features of the community resilience include readiness to face adversity, capability and eagerness to overcome, strong commitment to survive and collective actions (McAslan 2011). Resiliency is necessary to challenge impacts of climate change and disasters, to reduce damages and losses, and to recover quickly from the unpleasant situations. Thus, this study has assessed community resilience to climate change and disasters to understand capabilities of the community to minimize the effects. A number of approaches assess vulnerability of a community: Sustainability Livelihood Approach (SLA), SIP (Socioeconomic, Institutional and Physical) approach, Climate Disaster Resilience Index. However, this study has used Sustainability Livelihood Approach to assess community resilience to climate change and natural disasters.

2.1 Sustainability Livelihood Approach (SLA)

Climate change and natural disaster affect livelihood of the people severely. Therefore, greater emphasis has been given particularly for developing sustainable livelihood to enhance resilience to climate change and disasters. Department for International Development (DFID 1999) defined sustainable livelihood as "*A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future while not undermining the natural resource base*". Sustainable livelihood reduces adversity of climate change and disasters through eliminating poverty (Majale 2002). Sustainable Livelihood Approach (SLA) analyses the vulnerability of the people to respond and adapt to climate change and disasters. Moreover, SLA explores available resources of the household to overcome adverse situations and develop sustainable livelihood of the households. SLA describes a framework (Fig. 1) considering vulnerability context, institutional access and household capitals that affect resilience (Meena 2007). People are placed at the centre of an interactive network in the SLA framework and they have access to multiple capital resources around them that can improve their livelihood (IFAD 2001). The capital resources include: Natural Capital (e.g. land, water, biodiversity); Physical Capital (e.g. housing, water, sanitation, energy, transport infrastructure); Human Capital (e.g. health, knowledge, skills); Social Capital (e.g. networks, affiliations, associations, membership), and Financial Capital (e.g. remittances, pensions, savings, credit/debt) (Majale 2002; Morse 2009).

Access to the capital resources is significantly influenced by vulnerability contexts (e.g. economic, technological changes, disasters, production, employment opportunities). Moreover, social, institutional and political changes affect access to resources. However, sustainable livelihood is critical for reducing poverty, improving capacity to mitigate risks of climate change and disasters. Sustainable livelihood allows people to meet their needs and concurrently ensure available

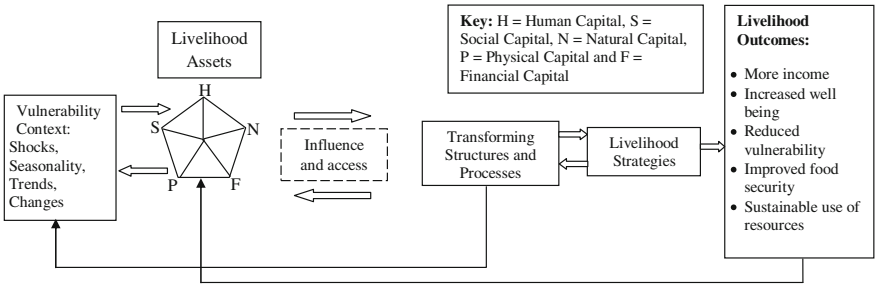

Fig. 1 Sustainability Livelihood Approach Framework. *Source* Conceptualized from DFID (1999), Meena (2007)

resources for the future generation to meet their demands. Therefore, using resources in sustainable way reduces poverty, vulnerability and food insecurity, increases household income despite various vulnerable contexts.

2.2 Conceptual Framework

A comprehensive literature review was conducted to develop a conceptual framework (Fig. 2). The literature reviews demonstrated that various manmade and natural factors (e.g. urbanization, industrialization, poverty, deforestation, wetland reduction, climate change, disasters) pollute and damage environment severely. Negative impacts of climate change include sea level rise, natural hazards, food scarcity, deforestation, unbalanced ecosystem, coastal zone inundation, poverty. This alarming situation induces world leaders to formulate agreements, protocols,

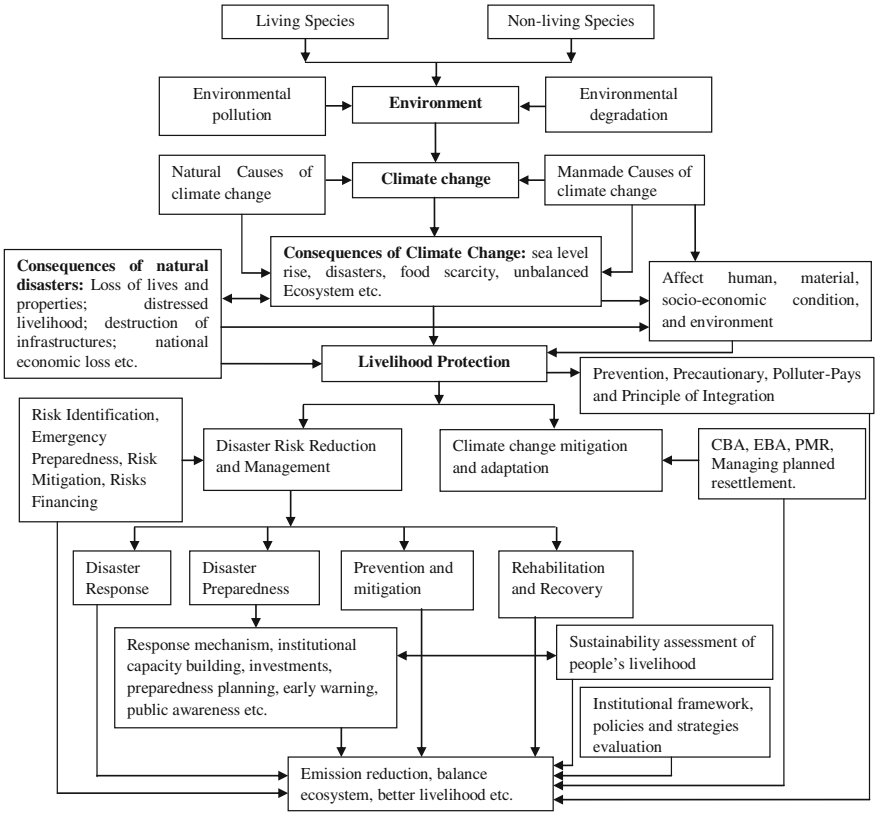

Fig. 2 Conceptual framework of this study. *Source* Conceptualized after reading various reference materials

plans, policies to protect environment, improve quality of life and reduce climate change and disasters risks. Moreover, people are implementing various measures such as community based adaptation, ecosystem based adaptation, planned resettlement for climate change mitigation and adaptation. Additionally, different instruments such as Prevention, Precautionary, Polluter-Pays and Principle of Integration can reduce GHGs emission and thereby environmental pollutions.

Numerous measures (e.g. risk identification and mitigation, risks financing, emergency preparedness) are undertaken for disasters risk reduction and management. Various literatures suggest that disaster response, preparedness, prevention and mitigation, and rehabilitation and recovery are the key factors for disaster risk reduction and management. However, scope of this study is limited to assess disaster preparedness of the people to reduce impacts of disasters. Measures of disasters preparedness contain enhancing coping mechanisms, disaster insurance, institutional setup, investments, hazards risks assessment, response mechanism and strategies, preparedness planning, early warning system, public awareness raising programs. These measures can reduce loss and damage of lives and properties; develop balance ecosystem and better livelihood of the people. The study has investigated the effectiveness and efficiency of different preparedness measures. Moreover, livelihood sustainability was assessed to explore available resources and obstacles to achieve climate change and disasters resilient community. Finally, an effort was given to evaluate efficiency, effectiveness, relevance and sustainability of institutional framework, plans, policies and strategies.

3 Study Area and Data Collection

The geographical context of this study is Cox's Bazar Sadar Upazila. Cox's Bazar with an area of 2491.86 km^2 and 1,757,321 populations is the most Southern-Eastern district of Bangladesh. It is situated along shoreline and immediate adjacent to the Bay of Bengal which makes it most vulnerable districts of the coastal region of Bangladesh. It has the longest (about 120 km) and beautiful sea beaches in the world. However, this district is a critical victim of climate change and disasters (e.g. flood, cyclone, tsunami, hurricane) due to its geographic location. Considering this Cox's Bazar Sadar Upazila was selected as a case for this study.

The key methods for conducting this study were desktop research; data collection through questionnaire survey and key informants interview; data input in SPSS and Excel, processing and analysis. Literature review was conducted through desktop research to understand different aspects of climate change and disaster management by reviewing relevant reports, journals, and international cases which helped to develop conceptual framework of the study. A preliminary literature review was carried out to develop theoretical background and understand the impacts of climate change and disasters, climate change mitigation and adaptation. A comprehensive literature review was conducted to develop conceptual framework of the study. Primary data related to socio-economic condition, preparedness of the

people were collected from the study area through household questionnaire survey, checklist, key informant interview and expert opinions. This study used random sampling method to collect data from the respondents in the study area.

Following sample size determining formula was used to calculate sample size in the study area (Yamane 1967).

$$n = \frac{N}{1 + Ne^2}$$

Here, n is the sample size, N is the total number of population in the study area (97,898), e is margin of error (5%). Using the formula the estimated sample size was 398. However, a total 100 questionnaires (50 from urban areas and 50 from rural areas) were recorded to know the scenarios of both rural and urban areas due to resource and time limitation. Using SPSS and MS excel collected data was analyzed. Simple descriptive statistics were presented and compared in table, figures. Disaster preparedness and resilience to climate change and disasters were also evaluated based on the collected data.

4 Results

This section analyses collected data (e.g. socio-economic, environmental condition, available resources, climate change and disasters impacts and situation) to assess disaster preparedness and climate change adaptation strategies of the people in the study area.

4.1 Socio-economic Condition of the Respondents

This sub-section investigates socio-economic strengths and weaknesses of the respondents to evaluate their readiness to disaster management and climate change mitigation in the study area.

Table 1 describes that most of the respondents (about 58%) are involved in agricultural, Fisheries/Livestock/Poultry related activities which are much higher than the national average (i.e. 36.1% family heads are involved in Agricultural, Animal Husbandry, Forestry & Fisheries). However, they have only 1–2 acres of land for agricultural purposes. In contrast, very few people are unemployed or retired (about 2%) compare to the national rate (about 17.6%). A significant number of respondents in the urban areas involve in business (about 24%) and service sector (about 20%) which is higher than the rural areas due to better opportunities and facilities in the urban area. Conversely, about 38 and 18% respondents involve in fisheries/livestock/poultry sectors and work as day laborer respectively in the rural areas. Moreover, this study has found that about 94% respondents own houses in the study area. All the households in the rural areas own houses. In contrast, about 88% respondents have houses in the urban area.

Table 1 Occupation of the family head of the respondents

Occupation of the family head	Area		Whole study area (%)
	Urban area (%)	Rural area (%)	
Farmer	40	32	36
Business	24	4	14
Service holder	20	2	11
Day labor	0	18	9
Fisheries/Livestock/Poultry	6	38	22
Retired	4	0	2
Other	6	6	6
Total	100	100	100

Source Field Survey, April, 2013

During field visit and key informant interview with Executive Engineer of Cox's Bazar Municipality the study found that agricultural lands, sea, river, marine resources including flora and fauna, hills, forestry, livestock/poultry are the main resources in the study area. Deputy Commissioner (DC) of Cox's Bazar district also mentioned that fishery resources in the Bay of Bengal are the main resource of this district. Moreover, the fisheries sector has a great impact on the local economy because a large number of people depend on this sector for their livelihood purposes. DC also mentioned that sea beach attracts huge tourists every year. Therefore, the area has huge potentiality of tourism development and earns foreign money. Many private investors are now investing in this area due to greater potentiality that strengthens local economy. They also mentioned that agriculture and marine fisheries are the main income sources of the people in the study area. However, both of these sectors are very vulnerable to climate variation and disasters due to salinity intrusion, sea level rise, floods, drought which are destroying agriculture, fisheries and biodiversity in the study area. Thus, proper initiatives are necessary to protect agricultural and fishery resources from severity of climate change and disasters.

Table 2 shows that monthly family income of the most of the respondents (about 36.36%) is about BDT 10,000.00 or less followed by BDT 10,001.00–15,000.00 (about 24.24%). In contrast, monthly family income of very few people (about 5.05%) is BDT 25,000.00 or higher. Bangladesh Household Income and Expenditure survey in 2010 found that average monthly household income is BDT 11,480.00. Particularly, average monthly household income in urban and rural areas is BDT 16,477.00 and BDT 9648.00 respectively (BBS 2011). Average income in the urban areas is greater than the rural areas due to various working opportunities in the urban areas. However, the level of income is insufficient for a household containing 4–7 members. Previously, this study found, agriculture and fisheries activities are the main sources of income in the study area. But, climate change and recurrent disasters destroy agricultural and fisheries production and reduce household income.

Table 2 Monthly family income of the respondents

Monthly income	Area		Whole study area (%)
	Urban area (%)	Rural area (%)	
≤ 10,000	14	59.18	36.36
10,001–15,000	26	22.45	24.24
15,001–20,000	22	8.16	15.15
20,001–25,000	10	0	5.05
≥ 25,000	10	0	5.05
Refuse to answer	18	10.2	14.14
Total	100	100	100

Source Field Survey, April, 2013

Table 3 Sources of cooking fuel for the households of the respondents

Source of cooking fuel	Area		Whole study area (%)	National* (%)
	Urban area (%)	Rural area (%)		
Wood	60	62	61	34.8
Kerosene	4	0	2	1
Gas/LPG	32	2	17	12.6
Straw/Leaf/Dried cow dung	4	36	20	51.7
Total	100	100	100	100

Source Field Survey, April, 2013; *(BBS 2011)

Table 3 shows that most of the people (about 61% in whole area, 60% in urban area and 62% in rural area) use wood for their cooking purposes in the study area. About 32% respondents in the urban area reported that they use gas/LPG for cooking purposes. In contrast, about 36% respondents in rural areas mentioned that they use Straw/Leaf/Dried cow dung for their cooking purposes. However, about 51.7, 34.8 and 12.6% people use Straw/Leaf/Dried cow dung, wood and Gas/LPG respectively as cooking fuel in Bangladesh. As a result, most of the people go without food, get dried stocked food during disasters as they cannot cook food due to lack of wood, leaf, straw during disasters.

The study also found that most of the respondents (about 56% in the whole area, 46% in urban area and 66% in rural area) own water tank/tube-well for water supply (Table 4). About 48% respondents have connected water line to house/tap for water supply in the urban area. In contrast, about 26% respondents collect water from public water points. However, most of the people in Bangladesh (about 89.1%) collect water for household purposes from own water tank/tube-well. As a major source of water, tube-well should be well protected to supply sufficient water during and after disaster. Ill-managed water supply system could bring water borne diseases due to infiltration of diseases causing agents into the pipelines of the water sources.

Table 4 Sources of water for households purposes of the respondents

Source of water	Area		Whole study area (%)	National* (%)
	Urban area (%)	Rural area (%)		
Connected water line to house/Tap	48	2	25	8.1
Own water tank/tube-well	46	66	56	89.1
Public water point	6	26	16	1.2
Pond/Lake/River	0	6	3	1.7
Total	100	100	100	100

Source Field Survey, April, 2013; *(BBS 2011)

Table 5 Structure types of the dwelling units of the respondents

Type of the structure	Area		Whole study area (%)	*Cox's Bazar Sadar Upazila (%)
	Urban area (%)	Rural area (%)		
Jhupri	6	18	12	15.5
Kutcha	8	40	24	64.97
Semi-pucca	52	38	45	13.28
Pucca	34	4	19	6.73
Total	100	100	100	100

Source Field Survey, April, 2013; *(BBS 2001)

Table 5 shows that a significant number of respondents (about 45% in the whole study area, 52% in urban area and 38% in rural area) have semi-pucca dwelling units. About 34% respondents have pucca dwelling unit in the urban areas that are less vulnerable to disasters. In contrast, about 18% and 40% respondents in the rural areas have Jhupri and Kutcha dwelling units respectively that are very vulnerable to disasters. The study also found that about 64.97 and 13.28% households have Kutcha and Semi-pucca dwelling units respectively in Cox's Bazar Sadar Upazila. These types of structure could be easily destroyed by heavy rain and wind. Recently, some pucca buildings have collapsed due to improper planning, layout design and using low quality of building materials. Therefore, proper steps should be taken to maintain quality construction and protect them from destruction.

Table 6 shows that about 52% dwelling units have Straw/Bamboo/Polythene/Plastic/Canvas walls in the rural areas. In contrast, most of the dwelling units (about 78%) in urban area have brick/cement walls. However, about 40.6% households have used Tin (CI sheet), 26.1% Brick/Cement, 16.6% Straw/Bamboo/Polythene/Plastic/Canvas and 16.6% Mud/Un-burnt brick for building wall in Bangladesh. These brick/cement walls are stronger and durable than Straw/Bamboo/Polythene/Plastic/Canvas and other materials listed in the table. However, people cannot afford stronger and durable materials due to poverty and low income. As a result, buildings easily collapse and destroy during disasters.

Table 6 Material types of the wall and Roof of dwelling units of the respondents

Material types	Urban area (%)		Rural area (%)		Whole study area (%)		*National (%)	
	Wall	Roof	Wall	Roof	Wall	Roof	Wall	Roof
Straw/Bamboo/ Polythene/Plastic/ Canvas	10	8	52	40	31	24	16.6	4.8
Mud/Un-burnt brick	6	52	6	52	6	55	16.7	83.0
Tin (CI sheet)	6	0	12	4	9	2	40.6	1.5
Brick/Cement	78	34	30	4	54	19	26.1	10.7
Total	100	100	100	100	100	100	100	100

Source Field Survey, April, 2013; *(BBS 2011)

The study also found that most of the dwelling units (about 55% in the whole area, 52% in both urban and rural area) have Tin (CI sheet) shade roof. About 34% respondents in the urban area have used brick/cement (concrete) for the roof which is almost absent in the rural area (about 4%). In contrast, about 40% respondents in the rural area have used weak and non-durable Straw/Bamboo/Polythene/Plastic/ Canvas for roof that can easily be destroyed during disasters. However, most of the households (about 83%) in Bangladesh have Tin (CI sheet) shade roof because Tin (CI sheet) is stronger and durable than Straw/Bamboo/Polythene/Plastic/Canvas. Therefore, a large number of households in the study area are vulnerable to disasters due to lack of strong materials for the roofs. Moreover, most of the household (about 64.29%) in the rural area have mud floor, a common scenario in all villages of Bangladesh. A significant number of respondents (about 35.71%) in the rural area also have brick/cement floor. In contrast, brick/cement (about 81.82%) is widely used as floor material in the urban area. Surprisingly, about 18.18% respondents in the urban area have mud floor which indicate their low socio-economic condition. The study found that housing structures in the study areas are vulnerable to disasters. So, proper initiatives should be undertaken to improve the socio-economic condition of the people to build better housing structure.

4.2 Preparedness of the Respondents

This study also investigated the preparedness of the respondents to reduce climate change and disasters risks in the study area. Questionnaire was designed particularly to understand perception of the people about climate change and disasters and simultaneously their state of preparedness to reduce risks. This section describes the condition of preparedness of the people.

4.2.1 Climate Change Perception

A large number of studies in the literature described causes and effects of climate change in the world. Similarly, this study also investigated climate change scenarios and perception of people about climate change. Impacts and perception of the people were evaluated to check effectiveness of different awareness raising programs, projects, campaigns, trainings conducted by government and NGOs (Fig. 3).

Conducting household questionnaire survey this study found that most of the people are familiar with climate change and its impacts on human and environment. About 14.2% respondents reported that environmental changes due to natural and manmade reasons are responsible for global climate change. Many respondents thought that variations in temperature (25.6%), rainfall (27.3%) and agriculture/fish production reduction (21.6%) demonstrate climate change in the study area. In contrast, only 2.3% respondents have no idea about climate change. Moreover, about 70.79% respondents reported that climate change has significant negative impacts on people, plants, agricultural production, fisheries, and other environmental resources. Mention worthy impacts of climate change include agricultural production reduction, increase of production cost, deterioration of people's living condition, disruption of business activities, income reduction, loss of biodiversity. Therefore, considering the critical role necessary strategies should be adopted to prevent climate change and disasters in the study area for the betterment of the people.

Furthermore, Executive Engineer of Cox's Bazar municipality has mentioned that forest resources destruction, hill destruction, heavy construction on seashore side are the main reasons of climate change in the study area. Consequently, variation in rainfall and frequent occurrences of floods due to heavy rainfall (e.g. flood in 2012) are common in the recent years. Flash flood is also a serious problem in this area since it occurs abruptly with water flow coming from the hilly regions. For example, flash flood in 2011 affected 66 unions of the Cox's Bazar district including 10 unions of Cox's Bazar Sadar Upazila and seven people were reported death. Besides, land slide due to forest destruction, hill cutting and heavy rainfall is

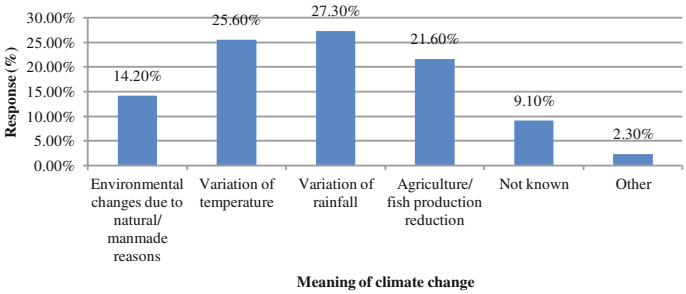

Fig. 3 Respondent's perceptions about climate change. *Source* Field Survey, April, 2013

another acute problem in the area. People of Cox's Bazar municipality experienced land sliding in 2010 when one person was reported dead.

Another Key Informant, Deputy Commissioner (DC) of Cox's Bazar district, reported that climate change is a global burning issue. However, investigating causes of climate change in the local level is very difficult due to some illegal activities (e.g. deforestation, hill cutting). Despite local authority and forest department have taken some initiatives to prevent deforestation and hill cutting but failed to control due to some political interventions. However, forest department has taken social forestation program namely 'Sobuj Bestony' to increase forest area and to mitigate climate change impacts in the study area. Although climate change is a global issue, all countries of the world are not responsible for global climate change. Every country of the world is being affected mostly by climate change especially the coastal areas of developing countries like Bangladesh. Climate change has negative impacts on the local biodiversity which is appearing recently. For example, he mentioned that few years ago there were lots of red crabs on the sea beach but it has reduced in a considerable number in the last few years. Also nowadays, many tortoises and corals are found dead in the sea beach. As biodiversity is an important element of the environment and a precious resource for attracting tourists, therefore, it should be preserved and protected through proper initiatives by the government and concerned agencies.

Table 7 represents available practicing strategies of climate change adaptation in the study area. Among them early planting and early harvesting, floating bed plantation, social forestation are widely practiced. Moreover, awareness raising activities, formation of community based organizations for collective adaptation and mitigation are undertaken to combat climate change and disasters. In contrast, people do not practice other effective strategies (e.g. salt and submerge tolerant crops introduction, rain water harvesting technology, income generation activity, behavioral change to reduce waste generation & air, water & land pollution) widely in the study area due to lack of awareness, inadequate modern technology and lack of funding. Furthermore, government, NGOs, donor agencies do not have any significant contribution for adopting effective strategies. However, they can enhance climate change adaptation capacities of the people by conducting awareness arising programs (e.g. training, campaigns, short drama), implementing modern technology, encouraging people (e.g. through providing incentive, subsidy) to initiate income generating activities (i.e. construction of culvert, bridges).

Table 8 represents that people are very concerned about flood, cyclone, earthquake and tsunami. About 7.3 and 52.1% respondents are extremely and very concerned for flood and about 22.7 and 32% respondents are extremely and very concerned for cyclone due to location of their households along the seashore and extremely vulnerability to climate change and disasters. In contrast, about 46.3% respondents are not much anxious about cyclone but recommended for proper mitigation and adaptation measures to reduce the devastation.

People are not much concerned about landslide and bush fire because it rarely happens in Bangladesh. However, few landslides are reported in the study area due

Table 7 Available climate change adaptation strategies

Climate change adaptation strategies	Responses	
	Total Responses	%
Early planting and early harvesting	18	19.8
Introduction of short duration crops	4	4.4
Floating bed plantation	10	11.0
Introduction of salt tolerant, submergence tolerant crops	4	4.4
Irrigation facilities	3	3.3
Rain water harvesting technology	1	1.1
Social forestation	12	13.2
Involve in income generation activity	1	1.1
Awareness rising of the people	21	23.1
Peoples' behavioral change to reduce waste generation & air, water & land pollution	3	3.3
Formation of community based organization for collective adaptation and mitigation	14	15.4
Total	91	100.0

Source Field Survey, April, 2013

Table 8 Level of concern of the people about disasters

Disaster	Extremely concerned	Very concerned	Average	Less concerned	Not concerned	Total
Flood	7.3	52.1	33.3	7.3	0	100
Cyclone	22.7	32.0	36.1	7.2	2.1	100
Earthquake	1.1	15.8	46.3	27.4	9.5	100
Tsunami	1.1	10.6	35.1	38.3	14.9	100
Landslide	2.2	4.3	24.7	26.9	41.9	100
Bush fire	2.2	1.1	16.3	25.0	55.4	100

Source Field Survey, April, 2013

to heavy rainfall and unscrupulous hill cutting. So, proper control measures (e.g. rules and regulations) should be implemented to prevent hill cutting to avoid landslides.

Table 9 represents vulnerability of different elements and sectors (e.g. people, animal, plant, infrastructure, utility services, housing, agriculture and local economy) to the disasters. Many respondents reported that poor and distress people (about 19.4% said extremely, 61.2% high and 19.4% average), agricultural sector (about 14.4% said extremely, 53.6% high and 26.8% average) and animal (about 9.4% said extremely, 53.1% high and 32.4% average) are the most vulnerable and affected elements and sectors in the study area. Moreover, a significant number of respondents mentioned that local economy (about 7.9% said extremely, 48.3% high

Table 9 State of vulnerability of different sectors/elements to the disasters

Sector	Extremely	High	Average	Low	Very low	Total
People	19.4	61.2	19.4	0	0	100
Animal	9.4	53.1	34.4	3.1	0	100
Plant	7.2	41.2	38.1	13.4	0	100
Infrastructure	3.1	29.2	46.9	19.8	1.0	100
Utility services	3.2	25.5	43.6	26.6	1.1	100
Housing	6.1	52.0	37.8	4.1	0	100
Agriculture	14.4	53.6	26.8	5.2	0	100
Local economy	7.9	48.3	38.2	5.6	0	100

Source Field Survey, April, 2013

and 38.2% average) and housing sectors are vulnerable to disasters. However, about 19.8 and 26.6% respondents mentioned that infrastructure and utility sectors respectively are not very vulnerable to disaster. Therefore, considering the significance of those sectors and elements proper steps should be taken to protect them from the devastation and ensure economic development of the people.

4.2.2 Disasters Preparedness of the People

The study found that many families (about 84.85% in the whole study area, 82% in urban and 87.76% in rural area) in the study area are inadequately prepared to challenge disasters. Low income, unemployment, lack of resources and disaster management training etc. have made them vulnerable to disaster. In contrast, very few families (about 15.15% in the whole study area, 18% in urban and 12.24% in rural area) are adequately prepared (e.g. strong and protected household structure, save money for the future) to tackle devastation of disasters. However, it is necessary to provide appropriate assistance (e.g. monetary, training, resources) to enhance preparedness of the people. Moreover, interest free loan can be provided to initiate different income generating activities to make them financially solvent.

Similarly, the study found that many families (about 54%) rarely store foods for using during disasters. Rural peoples (about 58%) are more concern to store food than urban people (about 34%) due to availability of household commodities in the urban areas and easy to buy them regularly. In contrast, people in the rural areas buy foods and other necessary things from open market that normally held once/twice in a week. Additionally, people can consume their reserved food for only 1–2 days and they cannot use reserved foods for more than one week. Therefore, a scarcity of foods appeared during disasters. Sometimes, people collect food from their neighbors and local super market. However, the supply of foods and other goods are not adequate to meet people's demands. Besides, people receive relief foods from government, NGOs and donor agencies. Despite getting food from various agencies people should reserve some dry and non-perishable foods for their

own purposes and safety. Moreover, campaign should be conducted to encourage and persuade people to store food for using them during emergency periods to enhance their preparedness.

The study has found that about 92.78, 98 and 87.23% respondents in the whole study area, urban area and rural area respectively did not receive any disaster management training. Other respondents have reported receiving training on disaster preparedness (e.g. understanding and responding to warning system). Viewing the lack of training respondents were asked to know their willingness to receive any training. About 84, 83.33 and 86.05% of them in the whole study area, urban area and rural area respectively were positively responded to receive disaster management. Most of the respondents wanted training on disaster awareness raising (about 30.02%), prevent and reduce disasters risks, and search and rescue (about 22.2%) (Fig. 4). In contrast, about 16.7% respondents wanted training on both first aid and relief distribution activities. Disaster management training is essential to improve disaster preparedness of the people, reduce disaster risks. Disaster management training will equip people to disseminate warning efficiently, participate in search and rescue activities immediate after disasters, provide first aid to the affected people and participate in relief distribution activities in an integrated way which ensures cost effectiveness of disaster management activities.

Table 10 shows that water tank/tube-well is the main source of water during emergency situation. About 58.43% respondents collect water from their own tank/tube-well in the whole study area. Similarly, many people in urban and rural areas (about 59.52 and 57.45% respectively) collect water from their own water tank/tube-well during disasters. Moreover, various government agencies, NGOs, and organizations provide potable water to the people. About 27.66% respondents in rural areas get water from emergency water supply from different organizations. So, people have adequate progress in disaster preparedness in emergency water supply.

The study found that about 54% respondents have sanitary latrine with water seal facilities in the study area (Table 11). However, most of the respondents (about 82%) in urban area and considerably low number of respondent (about 26%) in rural area have sanitary with water seal facilities. In contrast, about 36 and 38% respondents in rural areas have sanitary latrine without water seal and non-sanitary/Kutcha toilet facilities respectively. There are no communal and public toilet

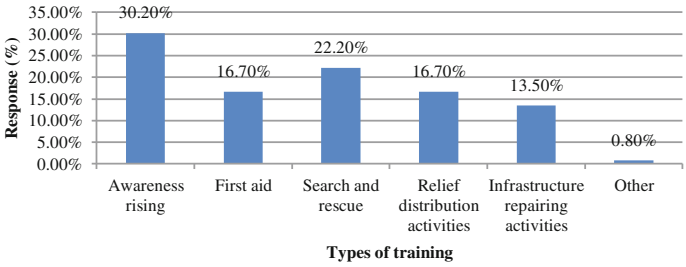

Fig. 4 Types of trainings respondent wanted to receive. *Source* Field Survey, April, 2013

Table 10 Sources of water during disaster

Source of water during disaster	Area		Whole study area (%)
	Urban area (%)	Rural area (%)	
Connected water line to house/ Tap	33.33	0	15.73
Own water tank/tube-well	59.52	57.45	58.43
Public water point	7.14	14.89	11.23
Emergency water supply	0	27.66	14.61
Total	100	100	100

Source Field Survey, April, 2013

Table 11 Types of toilet facilities of the respondents

Type of toilet facility	Area		Whole study area (%)
	Urban area (%)	Rural area (%)	
Sanitary with water seal	82	26	54
Sanitary without water seal	14	36	25
Non-sanitary/Kutcha	0	38	19
Communal toilet	2	0	1
Public toilet	2	0	1
Total	100	100	100

Source Field Survey, April, 2013

facilities in the rural areas. Similarly, very few people in the urban area use communal and public toilet facilities. While asking about toilet facilities during and after disaster, most of the respondents (about 90.24%) mentioned that their toilet facilities remain undamaged and they can use them during emergency situation. In contrast, different scenario was found in the rural areas where about 45.8% respondents reported that their toilet facilities damaged during disasters and they face acute problems. After huge damages and losses caused by disasters different organizations come to restore the facilities (i.e. rebuilding houses and other infrastructures). Simultaneously, they also provide materials for rebuilding toilet facilities.

Similarly, while asking about the condition of existing roads, about 51.06% respondents reported that condition of existing roads is not good to be used during emergency situation. However, the condition of the roads in urban area (about 63.83% respondents) is comparatively better than the rural roads (about 34.04%). Most of the roads in rural areas are narrow, muddy with partially pavement. As a result, the roads usually destroy during disasters and become unsuitable for communication.

Figure 5 demonstrates that a significant number of respondents (about 43.5%) mentioned about good surface condition of the roads. Roads are wide enough

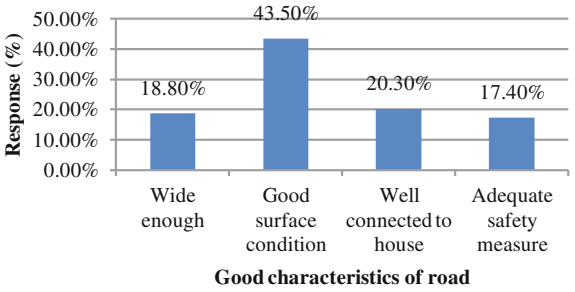

Fig. 5 Good characteristics of the existing road. *Source* Field Survey, April, 2013

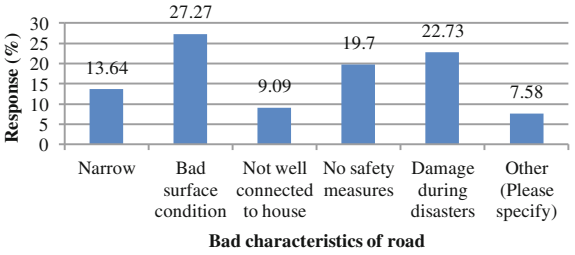

Fig. 6 Bad characteristics of the existing road. *Source* Field Survey, April, 2013

(about 18.8%), well connected to their houses (20.3%) and equipped with necessary safety measures. In contrast, about 27.73% respondents reported that roads become damaged during disasters (Fig. 6). About 27.27 and 19.7% respondents reported about bad surface condition and inadequacy of safety measures respectively. Therefore, they suggested improving road surface, wide road for facilitating both ways traffic movement, uplift level of roads from ground level for improving communication facilities. However, the key informant reported moderate level of service of the roads. The roads remain in operation during a disaster with low intensity and magnitude. But, the roads damaged severely and cannot use for emergency purposes during a disaster with high intensity and magnitude. Therefore, during emergency situation people substantially depend on water transport. Boats and speed boats become main means of transport for people. They are used extensively for remote distance transportation and for the emergency purposes.

Availability and execution of disaster early warning system strengthens preparedness of the people. This study found that almost all of the respondents (about 84.27% in the whole study area, 73.17% in urban area and 93.75% in the rural area) receive early warning from different agencies. Government organizations particularly involved with disaster management activities, news media, army/police, community based organizations/clubs usually provide early warning. Community based organizations/clubs (about 46.2%) are mainly responsible for issuing disaster warning followed by government organizations (about 30.2%). Moreover, about 16% respondents reported receiving early warning from news media (Fig. 7). However, key informants mentioned that there is a radar station in Cox's Bazar district. So, people also receive disaster early warning from the radar station.

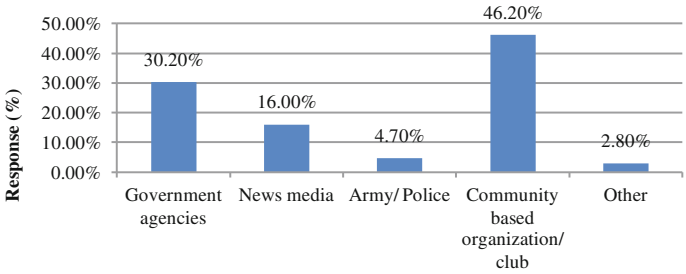

Fig. 7 Sources of disaster early warning. *Source* Field Survey, April, 2013

The key informant reported that there are trained volunteers in every community to disseminate disaster warning signal to the people. Comprehensive Disaster management Program (CDMP), a collaborative program of Ministry of Disaster Management and Relief and UNDP, mainly disseminates early warning. Besides, many NGOs have formed disaster management committees to provide early warning to the people. Timely dissemination of disaster warning is very essential for providing enough time to go to the safer places and consequently reduces damages and losses. Considering the importance, some respondents have suggested to use technologies (e.g. internet, mobile phone, radio and TV) to disseminate information quickly, efficiently and effectively.

From the field survey this study found that most of the people (about 56.2%) communicate with their friends, relatives and circulate disaster related information by telephone/mobile. Furthermore, radio/television (about 39.4% respondents) plays an important role as another means of information dissemination in the study area. In contrast, very few (4.4%) respondents receive disaster warning from newspaper. Due to the advancement of technology almost all people use mobile phone for their personal communication. However, usage of mobile phone was limited in Bangladesh before 2000 due to high price and unavailability of mobile phone. Recently, the usage of mobile phone has increased rapidly, even in the rural areas. Considering this scenario, mobile phone could be used more effectively as a tool of disaster management in Bangladesh. Mobile phone operators can send SMS to the subscribers to raise awareness about disaster management and provide early warning of disasters.

Table 12 represents that local government bodies (e.g. Union Parishad, Municipality) mainly provide emergency services to the people in the study area. About 81, 41.7, 55.6, and 77.8% respondents reported that local government provides foods, water, cloths and shelter facilities respectively during disasters. Moreover, NGOs play an important role because a considerable number of respondents (about 43.8 and 47.1%) reported that they provide treatment and sanitary latrine facilities respectively during and after disasters. Besides, other organizations and agencies (e.g. central government, army/police, Community Based Organization/Club, donor agencies) act closely for disseminating early warning information, providing basic services, involving in search and rescue

Table 12 Emergency service providers during disasters

Services	Central government	Local government	Army/ Police	Community based organization/Club	NGO	Donor agency	Total
Foods	1.3	81.3	2.7	6.7	8.0	0	100
Water	4.2	41.7	16.7	6.3	25.0	6.3	100
Cloths	16.7	55.6	11.1	16.7	0	0	100
Treatment	6.3	31.3	6.3	12.5	43.8	0	100
shelter	0	77.8	8.9	4.4	4.4	4.4	100
Sanitary facility	0	23.5	0	0	47.1	29.4	100

Source Field Survey, April, 2013

Table 13 Level of satisfaction on disaster preparedness services and activities

Services and activities	Very high	High	Moderate	Low	Very low	Total
Warning system	11.4	45.5	37.5	5.7	0	100
Search and rescue	7.5	78.8	12.5	1.3	0	100
Relief distribution	4.8	51.2	40.5	3.6	0	100
Shelter	1.2	20.5	38.6	36.1	3.6	100
Transport	1.3	5.0	46.3	43.8	3.8	100

Source Field Survey, April, 2013

activities, participating and providing financial assistance for rehabilitation of disaster affected people.

This study also investigated level of satisfaction of the people on available disaster preparedness activities and services (e.g. early warning system, search and rescue activities, relief distribution, shelter and transport services). Table 13 represents that many respondents are moderately and highly satisfied with the current disaster preparedness activities and services. For example, about 45.5, 78.8 and 51.2% respondents are highly satisfied with early warning system, search and rescue activities and relief distribution activities respectively. In contrast, about 38.6 and 36.1% respondents have moderate and low satisfaction respectively with the preparedness of shelter to accommodate people during disasters. Similarly, about 46.3 and 43.8% respondents reported their moderate and low satisfaction respectively with transport related services. Therefore, one can assume that people are moderately satisfied with the disaster preparedness activities and services in the study area.

During interview, the key informant mentioned that several government agencies (e.g. municipalities, Local Government Engineering Department (LGED)) and NGOs work on disaster risk reduction, enhancing disaster preparedness and climate change mitigation activities. Besides, 'Disaster Cell' under direction and supervision of Deputy Commissioner (DC), Cox's Bazar district conducts programs for enhancing disaster preparedness of the people. However, the informant

Table 14 Ways of assisting people during disasters by the respondents

Ways of assisting people	Responses	
	Total responses	%
Providing foods	40	26.7
Providing economic support	17	11.3
Participating in search and rescue	42	28.0
Providing healthcare/children facilities	20	13.3
Participating in infrastructure repairing activities	10	6.7
Persuading government, NGOs etc. for providing relief service	20	13.3
Other	1	0.7
Total	150	100.0

Source Field Survey, April, 2013

acknowledged the contributions of NGOs for disaster risk reduction and climate change mitigation. NGOs with different government organizations arrange workshops, programs, campaigns to enhance awareness on disaster preparedness and disaster resilient communities. DC office coordinates these programs in an integrated ways to respond disasters as quickly as possible. However, the key informant mentioned that this arrangement can handle disasters with low scale and magnitude. So, the capacity of the concerned authorities need to enhance by providing necessary equipments, skilled manpower, financial assistance to tackle disasters with high scale and magnitude.

During field survey respondents showed eagerness to assist people (e.g. relatives, poor and neighbors) during the emergency situation. Many respondents (about 82.83% in the whole study area, 90% in the urban area and 75.52% in the rural area) expressed their willingness to help others. People in the urban areas are more interested to help others than people in the rural areas due to their better economic condition. Table 14 represents that about 28% respondents interested to participate in search and rescue activities which is an important component of disaster management. About 26.7% respondents wanted to provide foods to assist affected people. A significant number of respondents wanted to provide healthcare/children facilities (about 13.3%), persuade government, NGOs for providing relief service (13.3%) and provide financial support (about 11.3%). Besides, other respondents wanted to participate in infrastructure repairing activities (about 6.7%) as and when required. However, assistance from different organizations is necessary during emergency situation to alleviate distress.

Similarly, during the field survey the respondents showed willingness to spend money to develop disaster resilient community. About 43.3, 46.81 and 40% respondents in the whole study area, urban area and rural area respectively wanted to spend money for disaster resilient community.

Willingness to pay significantly depends on socio-economic condition and attitude of the people and severity of disaster at that particular area. Table 15 represents that many people (about 83.33, 82.61 and 84.21%) in the whole study

Table 15 People's willingness to pay for developing disaster resilient community

Amount to spend (in BDT)	Area		Whole study area (%)
	Urban area (%)	Rural area (%)	
<1000	82.61	84.21	83.33
1001–3000	17.39	10.53	14.29
3001–5000	0	5.26	2.38
Total	100	100	100

Source Field Survey, April, 2013

area, urban area and rural area respectively interested to pay BDT < 1000.00 to develop a disaster resilient community. Moreover, about 5.26% respondents in the rural area wanted to pay BDT 3001–5000 to develop disaster resilient community. Therefore, it is observed that rural people are more interested to participate in developing disaster resilient community which essentially indicates disaster severity in the rural areas than urban. Furthermore, during field survey the respondents provided some important suggestions and recommendations to develop an efficient disaster management system. The suggestions and recommendations include enhancing supports from government and community level organizations and coordination, engagement of community people in search and rescue activities, implementation of efficient disaster early warning system, timely execution of search and rescue activities and other post disaster activities, appropriate rules and regulations to comply with all requirements of infrastructure (e.g. building, road) construction. Therefore, proper initiatives of the government, appropriate rules and regulation and local supports are necessary to develop disaster resilient community to reduce damages and losses significantly.

4.3 Assessing Disaster Preparedness of the People

The above discussion illustrates that socio-economic condition of the people in the study area is not at the acceptable level due to low income and high expenditure with no savings, low literacy rate, reliance on agriculture/fisheries sectors which is susceptible to climate change, utilization of large amount of woods for cooking purposes. Most of the households are built by non-durable and weak materials which could be destroyed by a disaster of low magnitude. Sea level rise, saline water intrusion, rainfall changes and different disasters have significant impacts (i.e. moderate, severe and very severe) on people, plants, crop production, fisheries and other environmental resources. From the field survey it is also found that a significant number of people do not store food to consume during emergency periods, most of the roads are not suitable to use after disasters, different elements/sectors such as people, animal, plant, infrastructure, utility services, housing, agriculture and local economy are vulnerable to the disasters. Most of the respondents agreed

that their households are not prepared to tackle any disasters and they did not receive any disaster management training. However, during field survey they were interested to receive disaster management training. Most of the people receive disaster early warning and they are moderately satisfied with disaster preparedness activities. However, people do not rely on the existing system due to failures of early warning system in the history of disaster management elsewhere in Bangladesh.

In contrast, this study found limited preparedness of the people in the study area. Most of the households have electricity connection to get disaster related news from radio/TV. People have good relation with their neighbors with an intention to help each other during emergency situations. Most of the people have a clear idea and understanding about climate change and disaster management. During disaster most of the people get water for domestic purpose from their own tank/tube-well. Most of the people provide emergency food, financial help to neighbors and take part in disaster management activities. So, the above discussion indicates that disaster preparedness situation of the people in the study area is average or below average level. However, financial assistance, training and awareness raising programs can improve preparedness of the people.

4.4 Assessing Resilience of a Community

Literature review indicated that resilience of a community to climate change and disasters depends on existence of available resources, efficient institutional framework and external supports from government and NGOs. Resilient communities are able to cope up with disastrous situations and come back to the original state. The study used Sustainable Livelihood Approach (SLA) to assess resilience of the community based on their available resources, vulnerability, barriers and institutional framework. SLA analyses vulnerability of the people to respond to climate change and disasters. During questionnaire survey the study found that different livelihood assets of the people are inadequate with a decreasing trend. Environmental degradation is appeared due to high level of emission, discharge and unplanned management of those resources. Physical resources (e.g. roads, buildings) are inadequate and vulnerable to climate change and disasters. Literacy rate is very low but people have little knowledge about climate change and disasters. People have strong relation with neighbors and have strong willingness to help them during emergency situation. Economic condition of the people is not at the satisfactory level. Consequently, they could hardly save money for the future due to low income and high expenditure.

There is a lack of coordination among the agencies involved in climate change mitigation and disaster management in Bangladesh. Besides, Bangladesh is very vulnerable to climate change and disasters and people of the coastal areas are critical victims of that. People remain jobless in the dry season and during disasters. Accessibility of the people to available resources is influenced by political and

technological changes, climate change and disasters. Some unscrupulous political leaders destroy environmental balance by cutting trees and hills. So, overall situation is not favorable for the people to achieve sustainable livelihood. Considering the situation government and other organizations (e.g. NGOs) should take proper initiatives to ensure sustainable livelihood. Income generating activities, financial assistance, incorporating strategies of sustainable development, climate change mitigation and disaster risk reduction in every development activities, training and campaign could ensure sustainable livelihood of the people. Those measures could increase income, achieve food security, ensure sustainable utilization of resources, and reduce vulnerability of the people to climate change and disaster. Therefore, resilience of the community to climate change and disaster will be achieved.

The above discussion asserted low disaster preparedness of the people in the study area. Moreover, they are not resilient to the adverse effects of climate change and disasters. Physical interventions could be introduced in the affected areas to improve disaster preparedness and resilience of the people. Thus, efficient and systematic institutional frameworks could play an important role by establishing suitable institutional set up, improving coordination and cooperation among the agencies and formulating appropriate policies, strategies, programs.

5 Institutional Aspects

A comprehensive evaluation of institutional frameworks, policies and strategies for disaster management and climate change mitigation has been conducted and published elsewhere (Rahman et al. 2015). These documents were evaluated based on five evaluation criteria: relevance, effectiveness, efficiency, impacts and sustainability set by Development Assistance Committee (DAC) of Organization for Economic Cooperation and Development (OECD).

Table 16 represents evaluation matrix of the policies and strategies. Analyzing institutional framework, policies and strategies the study found that they are comprehensive, efficient and effective to achieve targeted goals and objectives. However, mostly these policies and proposals failed to achieve their objectives due to lack of proper integration and coordination, scarcity of resources, lack of transparency and accountability of concerned organizations. Many government departments and agencies, NGOs, donor agencies, and other interested parties are involved in disaster management and climate change mitigation activities in Bangladesh. Moreover, every development activity is considering climate change and disaster mitigation measures in plan formulation and implementation. Therefore, an integrated and efficient institutional regulatory framework is necessary for formulation and implementation of development activities targeting at reducing climate change and disaster risks. For example, California Climate Adaptation Strategy-2009 emphasizes coordination among related agencies for proper implementation of plans, policies and programs. In every district a common platform and coordinating unit could be established for enhancing coordination and

Table 16 Evaluation matrix of the policies and strategies

Policy/ Strategy	Relevance	Effectiveness	Efficiency	Impacts	Sustainability
National Adaptation Programme of Action (NAPA)	Relevant with the existing context (e.g. vulnerable socio-economic condition, exposure to climate change and disasters, resources vulnerability)	It has effective adaptation measures which face difficulties to implement	It reduces damages and losses and minimise disaster recovery and rehabilitation cost	High agriculture and fish production, improved early warning, disaster shelter, increase coastal forestation, and create jobs opportunity	Future generation will be benefited, provision of revision from time to time
Bangladesh Climate Change Strategy and Action Plan (BCCSAP)	Has short and long term programmes to socio-economic development, disaster risk reduction, climate resilient infrastructure development, institutional capacity building. So, it is relevant with the overall context.	Successfully and timely implementation of the plan achieve objectives. But, no significant achievement has been appeared due to political instability, low cooperation, misallocation of climate funds, no proper monitoring and supervision	Cost-efficient, proper carrying out the activities minimise the loss of properties and lives, minimise cost of post-disaster recovery and rehabilitation activities	No significant improvement has been appeared after commencing BCCSAP. However, all programmes will be implemented successfully and people will be benefited even after BCCSAP expiration	It includes necessary information at any time, prepared after a wide consultation of various stakeholders including poor and disadvantaged people
Coastal Development Strategy (CDS)	Very relevant in the context to change the situation for livelihood development, economic development, environmental sustainability, reduction of disaster vulnerability	Timely and successfully implementation achieves objectives. But, no considerable achievement has been appeared due to political instability, low	Community people join actively during implementation of the projects, programmes. More often indigenous measures are taken to implement the projects,	Improve coastal environment, achieve economic prosperity, ensure access to safe drinking water and adequate water for agriculture, create jobs opportunities, enhance	Present and future people will enjoy positive impacts, government will invest to uphold the situation, private investors and donor agencies will invest, revise regularly

(continued)

Table 16 (continued)

Policy/ Strategy	Relevance	Effectiveness	Efficiency	Impacts	Sustainability
		level of cooperation, misallocation of funds, no proper monitoring and supervision even though many development induced projects, programmes have been carried out	programmes which make it cost effective	capacity building, implemented awareness raising and safety net measures and reduce poverty	to include changing situations, priorities, interventions and technologies

Source Adopted from Rahman et al. (2015)

collaboration among agencies in Bangladesh. Different Municipalities, Upazilas and Union Parishads could act as a common platform for coordination among agencies. However, their institutional capacity should be increased to manage it proficiently. Adequate fund, and proper management and implementation should be ensured for sustainability of different policies, plans and programs. There should be a provision for legal actions for violating regulations, guidelines to ensure proper implementation of regulations and guidelines to enhance people's awareness.

6 Conclusion

Very often different countries (e.g. USA, Japan, Indonesia, Bangladesh) experience adverse situations due to climate change and climate induced natural disasters. Developing countries (e.g. Bangladesh) are facing the worst situation due to low socio-economic condition, high level of poverty, low adaptive capacity, and absence of technological implication. Therefore, this research was undertaken to assess disaster preparedness and climate change adaptation strategies of people in the coastal areas of Bangladesh. Analyzing data the study found that Bangladesh is an agricultural based country with low socio-economic development, poverty, high density, vulnerable infrastructure, fragile communication system, political instability. The study also found that disaster preparedness and resilience of the people are average or below average. Institutional framework and policies, plans, programs are comprehensive and capable to achieve targeted goals and objectives. But, due to lack of proper integration and coordination, scarcity of resources, lack of transparency and accountability we are far away from the desired outcomes. Moreover, coastal areas are very rich with various resources and facilities and they have potentialities to flourish. By proper management and employment of resources the overall situation of the coastal areas could be developed. Government should take some short term and long term strategies to reduce climate change and its impacts. Immediately mobilization of concerned organizations through a common platform can enhance cooperation and ensure transparency and accountability of those organizations. Regular arranging consultation, seminar, campaign to aware people and consequently change their behavior to reduce climate change. Various long term strategies such as carbon emission reduction through encouraging low carbon development, developing resilience of the societies and mainstreaming climate change issues into different development works can essentially reduce climate change risks and uncertainties. Therefore, through implementing various short and long term strategies and effective implementation of various policies and strategies climate change and climate induced disasters can be challenged efficiently in Bangladesh.

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Loving Glacier National Park *Online*: Climate Change Communication and Virtual Place Attachment

Salma Monani, Sarah Principato, Dori Gorczyca and Elizabeth Cooper

1 Introduction

1.1 Purpose of Study: Importance of Online Media in Climate Change Communication

Climate change is a reality, and its anthropogenic basis is well established as a fact amongst over 97% of climate scientists (Maibach et al. 2014). Yet, public opinions on climate change in many countries suggest that this reality is still in doubt. As Schäfer and Schlichting (2014) write, the reality of climate change is often "un-obtrusive" and "complex"—its long temporal and spatial scales are not easily manifested in the everyday lives of individuals, the science involved is multi-disciplinary and often theoretical, and the impacts are complicated as they intersect with economic, political, and other social factors. These factors all make communicating climate change a challenge and an essential topic for communication scholars.

Schäfer and Schlichting's article, which appears in a special issue on *Environmental Communication* (2014, 8.2) devoted to media and climate change communication, demonstrates that research on climate change communication has

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grown in the 21st century, reflecting growing media discourse on the subject. However, their meta-analysis of the field found that most scholarship focused on print media (67.5%), with surprisingly little attention to other forms of media (2014, 151, Table 3.3). Even though online platforms enjoy a prominent place in public communication, such sites received little attention (~17% of studies). To redress this imbalance, they called for more studies on other forms of media, including online media.

Our study responds to this call and adds to a growing body of scholarship that acknowledges the importance of online media in climate change communication. Rogers and Marres (2000) published one of the earliest studies that examines online media, while more recent explorations include Schäfer's (2012) literature review, and Koteyko et al.'s special edited issue of *Environmental Communication* (2015, 9.2). Studies range from attempts to better understand how ideologies manifest in online spaces (e.g., Matthews 2015) to evaluating the perceived effectiveness of the online communication tools themselves (e.g., Newell and Dale 2015). Our study fits within the latter category. While Newell and Dale assess how a variety of online social media and non-news website platforms (from Live-chat to Youtube) functioned across a multi-party Canadian research project and its practitioners, we turn our attention to a single, interactive 2D website designed to engage an educated college audience.

Using Glacier National Park (GNP) located in northwest Montana, United States, as a central focus, our primary aim is to test if, and how, place attachment can be utilized as a means to generate climate change concern online in 2D website settings. Such virtual settings, we hypothesize, provide a unique opportunity for communicators to inspire audience's awareness of climate change, especially in cases where individuals do not necessarily experience, or know how to make sense of the impacts of climate change in their day-to-day lives.

We review how our study fits within the broader literature of place attachment and climate communication. The review situates our choice of methods, and grounds the results, discussion, and recommendations we suggest for future studies on online place attachment and climate change communication.

1.2 Literature Review: Why Place Matters in Climate Change Communication

The concept of place attachment, a term coined by environmental psychologists Low and Altman (1992), refers to the bonds that individuals have with a place. Its components include ideas of place identity, dependence, and emotion (Brownlee et al. 2015; Devine-Wright et al. 2015; Hammitt et al. 2009; Kyle et al. 2005). Place attachment follows from a body of research on place-people relations that goes back at least to the 1970s (i.e., to geographer Yi-Fu Tuan's 1974 concept of *topophilia*). However, the first reference to place attachment in relation to climate change was

by Fietelson (1991) in a research paper published in *Global Environmental Change*. Fietelson contended that place attachments are possible both at a local level (especially to places that are proximal and lived in) and at a global scale and can be useful tools to engender climate change concern. Since Feitelson's article, a growing scholarship explores how place attachment plays a role in individuals' perception and acceptance of climate change realities and concern (e.g., Devine-Wright 2011; Brownlee et al. 2015; Devine-Wright et al. 2015; De Dominicis et al. 2015). Even as scholars caution that place attachments can promote negative climate change concern (e.g., Schoenefeld and McCauley 2015; De Dominicis et al. 2015), numerous findings support Feitelson's original hypothesis that place attachment is an important positive factor in engaging climate change concern (Adger et al. 2011; Brownlee et al. 2015; Devine-Wright 2011, 2013; Hess et al. 2008; Schweizer et al. 2013).

In considering the possibility of how specific places evoke place attachment, Schweizer et al. (2013) explored US national parks and wildlife refuges. They hypothesized that as physical, material places, which are also symbolic sites of national and regional meaning, such public places can inspire climate concern. Their analyses of on-site surveys from 16 such sites across the United States support this hypothesis. Thus, Schweizer et al. (2013) recommend that "communicators, interpreters, and managers" should "embrace the idea of changing the conversation of climate change by using the landscape as a storytelling and engagement tool" (58). In doing so, they add to a large literature emerging out of resource management, recreational, and tourism studies that highlight the pro-environmental potential of place attachment to public parks and natural resources (Brownlee et al. 2015; Farnum et al. 2005; Halpenny 2010; Hammitt et al. 2009; Tonge et al. 2015).

Communication scholars are also beginning to actively explore the concept's implications through communication theory and methods. For example, Scannell and Gifford (2013) surveyed a sample of the Canadian public. Their findings demonstrate that out of three message conditions—one framing climate change in local and familiar places, one framing climate change in global and general terms, and one with no message—the local messages were most effective at evoking climate change concern. Local places corresponded with place attachment, and the greater the place attachment, the greater the concern for climate change. O'Neil and Nicholson's study (2009), which is not explicitly about place attachment, but instead about visual and iconic representations and fear appeals, also supports the notion that local places matter in climate communication because they suggest a more concrete and tangible sense of connection to place.

Despite the growing literature linking place attachment to the perception of environmental concerns, the effectiveness of using place attachment as an online climate change communication strategy is not well understood. The neglect is surprising as numerous studies show that individuals develop and maintain attachment bonds to places presented virtually, whether through 3D tools (Goel et al. 2011; Guttentag 2010; Plunkett 2011, 2013; Schroth et al. 2014; Turner et al. 2005), photographs (Cheng and Kuo 2015), videos (Adams and Gynnild 2013),

maps (Farman 2012; Sandy and Franco 2014) or just text (Polson 2015). These bonds of connection are possible precisely because place attachment is multi-faceted. In place attachment, the physical encounter with a place is complemented by social and psychological elements that imbue senses of identity, dependence, and emotion that generate attachment bonds. All of these elements can occur online. For example, Plunkett, drawing on Harrison (2009), points to how even completely virtual reality spaces, such as the multi-player game *Second Life*, generate online place attachment by replicating real-world places of cultural significance which "foster a sense of 'rootedness,' community, and belonging" online (2011, 174). Schroth et al. (2014) is a rare study that shows that 3D interactive games with a focus on local environments can generate climate change concern.

Given this background, we hypothesize that using place attachment in a 2D online setting will generate climate change concern. Such settings are usually easier and cheaper to design than 3D gaming environments. Using a mixed-methods approach, our pilot study generated a 2D website to test the possibility of place attachment as a best practice in online climate change communication.

2 Methods

Following Schweizer et al.'s (2013) call for communicators to "change the story of climate change" (58) by paying particular attention to the role of places such as national parks and refuges (58), our study focuses its "*online* climate change story" on one national park, Glacier National Park (GNP) located in northwest Montana, United States (Fig. 1). To connect GNP as a place of potential visitor attachment with climate change as a concern, we: (1) designed a website to evoke senses of identity, dependence, and emotion central to place attachment while also

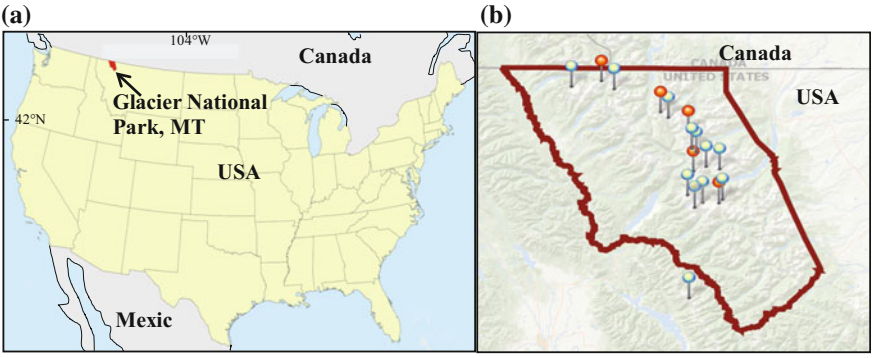

Fig. 1 **a** Location of Glacier National Park in northwest Montana, USA. **b** Map of 18 active glaciers (blue or light gray) and inactive glaciers (red or dark gray) used in the repeat photograph section of the website (There are currently 26 active glaciers in the part; however, only 18 glaciers have documented repeat photography.)

incorporating information on climate change science, adaptation, and mitigation; and (2) assessed visitors' sense of climate change concern at various geographic levels via pre- and post-website viewing survey analyses.

2.1 Creating a Climate Change Website Utilizing Place Attachment Strategies

The first step in our methodological procedure was to create a climate change communication website that utilized place attachment strategies. The website "Is it Hot out Here? Our Changing Climate at Glacier National Park" (Gorczyca 2015) was created using Wordpress, a content management system designed for ease of use, allowing customization without the website designer needing to be fluent in computer programming languages. The design incorporated five tabs in the main navigation bar: "Glacier National Park," "Glaciers and Climate Change," "Better Futures," "Just for Fun," and "Additional Resources." Respectively, they directed users to sub-tabs with the following: (1) information specific to the park's environmental history (cultural and scientific); (2) scientific information about glaciers and climate change; (3) climate change projections and possible individual actions, (4) a quiz and a space for audiences to share their own stories, and (5) additional web resources, where interested users could further explore the science of climate change and glaciers.

The website's targeted audience was students at Gettysburg College, a private, non-profit, residential liberal arts college located in south central Pennsylvania, USA. Most of the students are from the eastern U.S. and do not live in the vicinity of GNP. The choice of audience was both because of ease of access and because the average age of respondents (18–22 years old) makes them a particularly important demographic to study. As Corner et al. (2015a) write, this demographic is the generation whose lives will overlap most closely with the expected impacts and policy windows prescribed for climate change mitigation (2020–2050). Knowing how they respond to climate change communication is imperative.

To tailor information to this audience, we incorporated communication strategies understood as best practices across media platforms: clear, simple messages, transparent information and data, attempts to neither overwhelm nor depress, and awareness of the audience's expected characteristics (Corner et al. 2015b; Maibach et al. 2014; Schweizer et al. 2013; Wirth et al. 2014). For example, the website's design encouraged "free-choice, non-sequential, self-paced, and voluntary" (Falk 2005, 272) interaction; i.e., visitors have choice and control over whether and how they navigate the space. As Falk (2005) and Bell et al. (2009) suggest, such "free-choice" designed settings allow visitors to engage because they 'want to', instead of being 'made to.' Finally, the website focused on enhancing the three components of place attachment—identity, dependence, and emotion.

2.1.1 Identity

Place identity is the symbolic meaning a place has to individuals and communities (Kyle et al. 2005; Harmon 2006). The website intentionally used two important place identification strategies:

- *The symbolic value of national parks in the American collective imagination:*

Since the turn of the 20th century the U.S.'s national parks have been modeled as part of the country's heritage, where lands are set aside as public spaces for the use and enjoyment of current and future generations of Americans (National Park Service "Organic Act" 2015). Thus, national parks often prefigure as places of proud and positive national identification for many Americans. Founded in 1910, GNP is one of the country's oldest and best-known parks.

- *The importance of localized and individualized stories:*

The website draws attention to GNP's glaciers to make tangible the impact of climate change. Repeat photography highlights the rapid melting of GNP's glaciers, and an interactive table, which involved analyses of United States Geological Survey (USGS) data on the park's *individual* glaciers (Gorczyca 2015) shows how elevation (and rising temperatures) affect glacier melt. Such particularizing of GNP's glaciers' generates localized stories, which are understood as important motivators for identification (CRED & ecoAmerica 2014; Wiest et al. 2015). The site also incorporates a "Buzzfeed" quiz, "Which Glacier Are You?" which enables a quiz taker, through a series of personality questions, to *identify as* a specific glacier, thus fostering a personal connection.

2.1.2 Dependence

As Harmon write, "place dependence is conceptualized as the opportunities a setting provides for goal and activity needs" (2006, 149). Thus the website highlights that GNP's status as a national park depended on the presence of its glaciers, the "jewel in the crown" of the Rocky Mountains (sub-menu tab: "Glacier's Science and History"). The website also incorporates an audio clip and a quote of an interview with a local park ranger, Teagan Tomlin, to illustrate the dependence and interaction of the park's natural systems on the glaciers (sub-menu tab: "What Can You Do?"). Finally, it spotlights the general importance of glaciers to human societies, stating, "Glaciers provide clean drinking water for many people around the world" (sub-menu tab: "What is a Glacier, Anyways?"). Such narratives of dependence are linked to information on how rising temperatures are causing GNP's glaciers to melt rapidly. The sub-menu tab "Climate Change Projections" allows visitors to see the effects that climate change will have not just on GNP but on the globe as a whole. Such information is geared to help visitors understand how

climate change is altering the planetary resources on which humans and nonhumans depend.

2.1.3 Emotion

Because emotion is central to place-based attachment, the website strives to engage visitors' emotions in a number of ways. First, it follows Banse's (2013) "Seeing is Believing" and Corner et al. (2015b) "7 Key Principles of Visual Climate Change Communication" to work with visual imagery. The website uses ArcGIS's Storymap Template and USGS repeat photography imagery of individual glaciers to generate a visual series showing how each glacier has retreated over time (sub-menu tab: "Map: How Have the Glaciers Changed?"). Paired with a color-coded map that pinpoints individual locations of active and declassified glaciers, the interactive feature aims to tie iconic images of melting glaciers to this particular space. Numerous studies articulate the importance of such visually particularizing strategies to engaging emotional appeals (Corner et al. 2015a; DeLuca 2009; Doyle 2007; Leiserowitz 2006; O'Neill and Nicholson-Cole 2009).

Second, the website's language steers clear of fearful language, which can overwhelm visitors and generate psychological distance from the issue (Corner et al. 2015b; O'Neill and Nicholson-Cole 2009). Instead the language focuses on solution-appeals that highlight actions at international, national, and local levels, and how visitors can contribute. For example, the website links to the NPS's climate action plan, and the "Better Futures" tab suggests visitor actions for adaptation, mitigation, and positive change.

Finally, the website uses language and interactive design (e.g., the free-choice navigation, the inclusion of quizzes, links to upbeat videos and audio clips, and the ability of visitors to contribute their own stories) common to "edutainment." This form of messaging couches scientific issues in an informal and entertaining context, and is pedagogically useful in environmental education (Cordero et al. 2008; Flora et al. 2013).

2.2 Surveying Website Visitation

Once the website was created, the second step in our methodological procedure was to create a survey that could assess visitor's responses to the website. A survey was generated using SurveyMonkey to assess its effectiveness at heightening climate change concern.

2.2.1 Targeted Respondents

Given the demographic profile of Gettysburg College, targeted respondents were 18–22 years old, educated, from an economically privileged segment of the American population, and had leisure time to engage in activities offered by national parks like GNP. Because studies suggest that gender, political affiliations, and educational tracks play a role in climate change belief (Devine-Wright et al. 2015; Funk and Raine 2015; Hornsey et al. 2016; McCright and Dunlap 2011), the survey asked participants to self-identify these attributes. Gender choices included male/female/other. Political affiliations choices included Democrat (the main American political party identified as socially liberal), Republican (the main American political party identified as socially conservative), Independent, and Other. Educational tracks are identified as 'academic majors;' i.e., a student who chooses a course track in Biology is a Biology major.

2.2.2 Survey Design and Implementation

The survey was distributed via email to Gettysburg College students. Responses were anonymous. All survey respondents completed the survey during their own time. A portion of respondents received extra credit in their Introduction to Environmental Studies course if they participated. The survey had three components:

1. Initial questions. These included the demographic questions identified above. In addition, there were three questions on the respondents' climate change concerns at GNP, locally (in respondents' environments), and globally, respectively. Concern was rated on a Likert-scale from 1 (not at all concerned) to 5 (very concerned). Finally, the survey asked if respondents wanted to visit GNP, with Yes/No/Maybe options. This question was aimed to gauge initial place-attachment to GNP.
2. Viewing the website.
3. Final questions. The questions regarding concerns about climate change and desire to visit GNP were repeated. An additional question, aimed at gauging the immediate emotional impact of the site, asked "when you think about climate change mitigation, how do you feel about the future?" The Likert-scale rated responses on a scale of 1 (very depressed and hopeless) to 5 (hopeful and encouraged). A final comment box asked whether the website had changed a visitor's feelings on climate change.

2.2.3 Survey Analysis

The survey was available for three weeks in March of 2015. Only respondents who had completed all of the Likert-scale questions were considered in the analysis. The

Mann-Whitney U test was used to assess the difference in gender perceptions, differing political affiliations, and majors both before and after participants viewed the website. The Wilcoxon signed-rank test was used to determine the statistical difference in climate change concern for participants before and after viewing the website. Pivot tables were created to visually demonstrate how many participants moved up or down on the 1–5 scale after viewing the website.

The primary purpose of the survey was to yield quantitative data about climate change concern globally, locally, and at GNP. However, the comments in response to the survey's final question ("Did the website change your feelings?") prompted an additional qualitative assessment. While such an assessment was not accounted for when designing the survey, we adapted Schweizer et al.'s (2013) and the Leiserowitz et al.'s (2009) Six Americas Audience Segmentation categories, which we modified to reflect the question's focus on whether respondents' feelings towards climate change were altered from viewing the site. Thus, our categories are *Engaged; Aware and Affected; Aware and Unaffected; Apathetic; and Skeptical*. The categories Engaged, Apathetic, and Skeptical mirror Schweizer et al.'s (2013) adaptation of Leiserowitz et al.'s (2009) Six Americas categories. *Aware and Affected* and *Aware and Unaffected* overlap with the Six Americas' Concerned category, but capture the specific nuance of our survey. Both categories consist of individuals who are aware and concerned about climate change. However, while the former suggests the website has altered their perception of climate change, the latter does not. Neither group necessarily articulates a sense of personal action. Because this is a qualitative reading based on a single question and not a statistical cluster analysis of a series of questions as conducted by Schweizer et al. (2013) and Leiserowitz et al.'s (2009) study, we interpret the results with caution.

3 Results: Surveys

3.1 Demographic Data of Survey Respondents

120 undergraduate students from Gettysburg College completed the survey (Table 1). 54% of respondents were female, 44% were male, and 1% identified as other. 43% identified as Democrats, 30% identified as Republicans, 21% as Independents, and 5% as Other. The majority of the respondents were Environmental Studies or History majors, although many were also Biology, Economics, or Organizational Management Studies majors. The majority of respondents spent between 10 and 15 min on the website. 60% of the respondents (72) included text comments in addition to their survey ratings.

Table 1 Demographic data of survey respondents (n = 120)

Variable	Frequency	Percentage
Sex of respondent		
Male	54	45
Female	65	54.2
Other	1	0.8
Political affiliation		
Democrat	52	43
Republican	36	30
Independent	25	21
Other	7	6
Academic major		
Environmental studies	24	20
History	13	11
Undeclared	10	8
Economics	9	7.5
Organizational management studies	9	7.5
Biology	8	6.5
Psychology	7	6
Political science	6	5
Other majors	<5 per major	n/a

3.2 *Impact of Website*

After viewing the website, the vast majority of respondents (117 out of 120) reported an increased level of concern about climate change globally, locally, and at GNP (Fig. 2; Table 2). There is a statistically significant difference in the level of concern about climate change globally, locally, and at GNP before and after viewing the website ($p < 0.001$). The level of concern about climate change increased the most at GNP, and the increased desire to visit GNP before and after viewing the website is statistically significant ($p < 0.001$) (Fig. 3).

3.2.1 Gender

A statistically significant difference in responses based on gender was observed before respondents viewed the website, with females more concerned about climate change globally ($p = 0.007$), locally ($p = 0.001$), and at GNP ($p = 0.005$) (Fig. 4). After viewing the website, females remained more concerned about global climate change ($p = 0.01$), but there was no significant difference locally ($p = 0.145$) or at GNP ($p = 0.066$) based on gender.

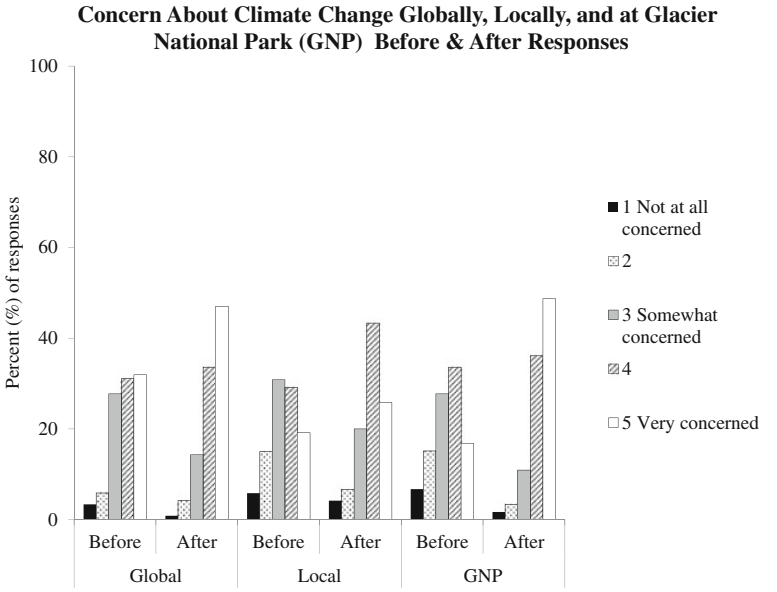

Fig. 2 Respondents level of concern (1 = not concerned through 5 = most concerned) about climate change globally, locally, and at GNP before and after viewing the website. A statistically significant difference in the level of concern about climate change globally, locally, and at GNP is observed before and after viewing the website ($p < 0.001$), with the greatest increase in concern at GNP

3.2.2 Political Affiliation

With respect to global climate change, a statistically significant difference in response based on political affiliation was observed before respondents viewed the website, with Democrats more concerned about climate change globally than Republicans ($p = 0.001$). However, the two political groups had similar responses about climate change locally and at GNP, and no statistical difference ($p > 0.05$) was observed before or after viewing the website. For these two groups, after viewing the website, there continues to be a statistically significant difference in responses to global climate change, but the difference narrows ($p = 0.026$). Responses from students that identified as Independents were very similar to Democrats. Because of the small sample size for survey participants that identified as "Other" political affiliation (n = 5) no statistical tests were run to compare with responses from Democrats or Republicans.

Table 2 Pivot table depicting change in level of concern about climate change at GNP before and after viewing the website

		GNP After					
		1	2	3	4	5	Total
GNP Before	1	2	1	2	3		8
	2		3	7	6	2	18
	3			4	17	12	33
	4				16	24	40
	5					19	19
	Total	2	4	13	42	57	118

Gray shaded boxes represent participants who rated their concern level higher after viewing website. No respondents rated their concern lower after viewing the website

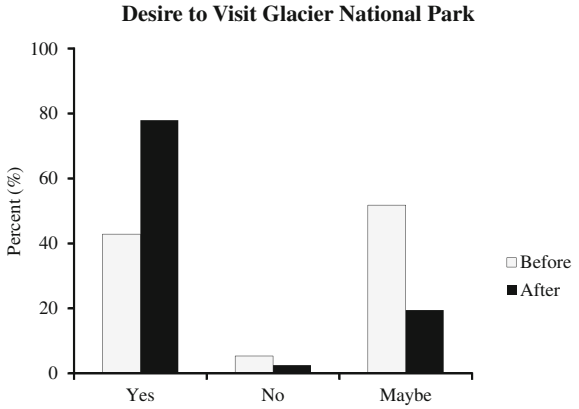

Fig. 3 Respondents desire to visit GNP before and after viewing the website. A statistically significant increased desire to visit GNP is observed ($p < 0.001$) after viewing the website, and very few respondents stated that they had no desire to visit the park

3.2.3 Educational Track (Academic Major)

Participants who identified their academic major as Environmental Studies were the most concerned about climate change compared to other majors, with high levels of concern (modal response of 5/very concerned) for climate change globally, locally, and at GNP before and after viewing the website. For students with other majors, the modal response before viewing the website was a concern level of 3 globally, locally, and at GNP. After viewing the website, students with other majors reported an increased level of concern about climate change, with modal responses of 5 for global climate change and at GNP and responses of 4 for climate change locally. After viewing the website, there was no statistically significant difference based on major for responses to climate change globally ($p = 0.026$) or at GNP ($p = 0.085$).

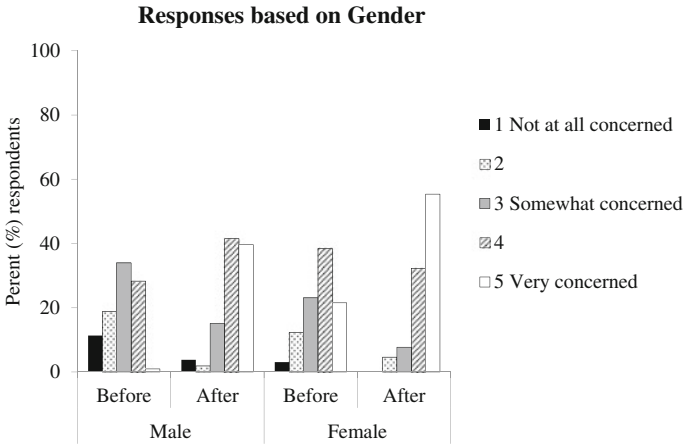

Fig. 4 Respondents' level of concern about climate change divided by gender before and after viewing the website. After viewing the website, there is no statistically significant difference in the level of concern based on gender ($p = 0.145$)

3.2.4 Respondent Comments: Categories of Audience Segmentation

Seventy-two respondents included written comments at the end of the survey. The comments ranged from one word to multiple sentences. Approximately 28% of the respondents specifically included GNP in their written comments about climate change. The majority of respondents believe in climate change (21% are *Engaged*, 33% are *Aware and Affected*, 29% are *Aware and Unaffected*) (Fig. 5). Only 6% of commentators appear *Apathetic* (3%) or *Skeptical* (3%). A sixth category of *Not Applicable* (11%) included answers (e.g. *went to website, will return later tonight when I have more time*) that did not provide sufficient insight into their climate change concern. The *Engaged* used language that indicated personal responsibility (I, we, our) in solving the problem, such as seen in this example: *I hope we can indeed create the tipping point the website talks about and everyone can help save the environment.*

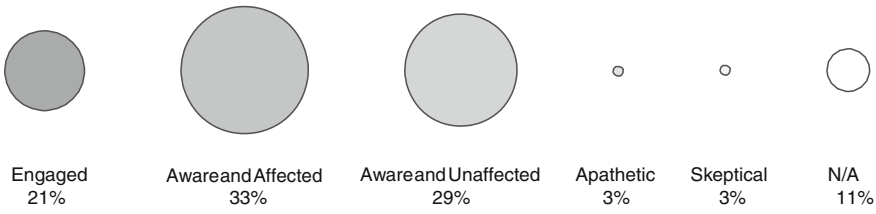

Fig. 5 Written comments from survey respondents divided into six categories adapted from Schweizer et al. (2013) and Leiserowitz et al. (2009). Not applicable (N/A) refers to comments that were one word answers or off topic (e.g., "I will finish the survey later")

The *Aware and Affected* category includes comments expressing climate change concern and a sense of learning from the website. However, there is an absence of personal responsibility, as suggested by this response excerpt:

> I feel a little better knowing that there are young people like yourself who are dedicating their time and efforts to this topic… I hope that your generation and other people studying this can make a difference for our future.

The *Aware and Unaffected* category includes comments that suggest that the website has not altered the level of concern of a respondent. Most respondents in this category state that they were already concerned about climate change, as articulated by this respondent: *Not particularly, I already was concerned about climate change.*

4 Discussion

4.1 Encouraging Climate Change Concern Across Demographic Differences

Our study hypothesized that place attachment can be employed as a strategy to effectively communicate climate change in 2D online environments, and designed a website and survey to test this. While less than half of respondents (42%) said they wanted to visit the park before engaging with the website, this number jumped significantly to 78% of respondents ($p < 0.001$) after engagement (Fig. 3), suggesting that the park's virtual presence had a positive impact on feelings toward the real GNP. As many others (Adams and Gynnild 2013; Cheng and Kuo 2015; Farman 2012; Goel et al. 2011; Guttentag 2010; Plunkett 2011, 2013; Sandy and Franco 2014; Schroth et al. 2014; Turner et al. 2005) have argued that place attachment is possible in virtual environments, this finding is not surprising.

In addition to increased attachment to GNP, survey results also show increased climate change concern at GNP, locally, and globally after respondents viewed the website (Fig. 2). The increase is highest for GNP, which suggests that the website's strategies to encourage place attachment to GNP are effective. Viewing the website also encouraged visitors to report higher concern for global and local climate change, supporting our hypothesis that encouraging attention to one place is an effective tool to engender a general concern about climate change. A number of respondent comments specifically remark how GNP makes global climate change tangible. As one respondent wrote:

> I learned a lot about the importance of parks like the Glacier National Park, and expanded my knowledge about various environmental impacts of climate change. Yes. The website has opened my eyes to the effects of climate change, specifically on a place like Glacier Park. I may be a little more concerned about the future of our environment.

Such statements are common amongst the respondents.

While the website encouraged overall climate change concern, our results suggest that strategies of place attachment might also be effective in tackling discrepancies in climate change concern associated with demographic parameters of gender, political affiliation, and educational interests. Our pre-survey results concur with earlier findings that males appear to be less concerned about global climate change and that conservatives are more inclined to be skeptical or dismissive. However, after viewing the website, these gaps diminish or disappear (Fig. 4). The change in gender results may be attributed to at least two related factors. First, prior notions of place identity may influence male respondents because of the website's focus on a national park, a type of space traditionally associated with masculinity. Second, according to McCright and Dunlap (2011), the gender divide in climate change concern is not necessarily related to value or belief differences between the two genders, but instead is a factor of learning habits and prior education. With free-choice 'edutainment' and GNP as entry points, male respondents may have been more inclined to educate themselves about the issue of climate change, which in turn, could increase their concern.

The website was also effective across self-identified political affiliations and educational tracks. As noted above, after viewing the website, self-identified Democrats and Republicans reported similar levels of concern regarding climate change at GNP. This suggests that GNP may serve as a site of bipartisan national pride, and can therefore be an important point of climate change engagement. It is not surprising that our pre-survey results show that Environmental Studies majors are most concerned about climate change. However, as post-survey results show no statistically significant difference based on academic major, the website appears to work effectively as a climate change communication tool across educational tracks.

These results make us optimistic that strategic online place attachment is effective. However, the particular profile of our targeted audience—college students—may help account for the change. As Corner et al. (2015a) write, "While worldviews are well entrenched among adult populations, during teenage years they are still forming and this 'plasticity' may explain why climate change knowledge mitigates worldview based skepticism among young people" (6; see also Lombardi and Sinatra 2012).

4.2 Respondent Comments: Variations in Climate Change Engagement

While the primary purpose of the study was to quantitatively survey climate change concern, inclusion of a comment box in the post-survey presented additional insights. As suggested above, many comments reiterate that place attachment is indeed playing a role in climate change concern. For example, this respondent writes:

> Putting a face on things and making it more evident what the changes are on a direct location always helps because you see the pictures and the beauty and you become a little bit more attached.

Given that young, educated, higher-income people are more likely to believe in climate change (Funk and Raine 2015; Hornsey et al. 2016), it is not surprising that the majority of comments from our target audience acknowledge concern. However, as our results, which adapt Schweizer et al. (2013) and Leiserowitz et al.'s (2009) audience categories, suggest, there is a range of ways in which concern is engaged—whether in articulating personal responsibility or not. The majority of responses (62% were either *Aware and Affected*, or *Aware and Unaffected*) do not necessarily express personal responsibility, which fits with prior studies that suggest that many young people experience psychological distance from climate change (Corner et al. 2015a; Ojala 2012; Smith and Leiserowitz 2014). Negative emotions reported by 8% of respondents (words such as hopeless, fear, sadness) are also not surprising since previous studies show that young people often feel disempowered in the face of climate change (Corner et al. 2015a; Smith and Leiserowitz 2014). Despite these psychological barriers, there are a number of hopeful comments (30%) such as when respondents refer to the website's suggested solutions to climate change. These more positive responses suggest that the website is encouraging climate change concern and mitigation and adaptation possibilities.

5 Conclusion: Online Place Matters

The results of our study indicate that 2D online settings can effectively use strategies of place attachment to prompt climate change concern. Thus, we encourage place attachment as a best practice in online climate change communication. In addition, based on the limitations and successes of this pilot study, we encourage climate communication scholars to consider the five recommendations we outline for future studies.

5.1 Recommendations for Future Studies

5.1.1 Strategically Creating Websites for Specific Audiences

Based on the success of our pilot study, we recommend free and open software to generate websites that incorporate place attachment into online climate change communication. We encourage practitioners who create websites to strategically consider the role of identity, dependence, and emotion when focusing on a place to showcase. Our website wove these central elements of place attachment into its design with particular attention to its specific audience—college students. Future

studies can and should continue to engage this demographic because, as suggested earlier, this is a generation that will have to reckon directly with climate change. The study can be replicated in other college, school, or educational settings.

While the respondents in our study were all college students, we recommend that future studies test how audiences of broader educational and age backgrounds respond to online place attachment. Do the shrinking gaps in climate change concern we observe across political ideologies, genders, and educational tracks in our participants also occur in other segments of society? Future studies can help analyze why and how place attachment works as a 'depolarizing' agent.

5.1.2 Intentionally Designing Surveys for "Audience Segmentation"

Our study's survey design did not intentionally account for audience segmentation as suggested by Schweizer et al. (2013) and the Leiserowitz et al. (2009). While this was a limitation of our study, because the comments yielded interesting qualitative data, we were able to generate a grounded analysis that drew from these two important studies to consider how visitors segment in their climate change biases. We recommend that future studies design their surveys to explicitly incorporate the quantitative methods used in the Schweizer et al. (2013) and the Leiserowitz et al. (2009) to better capture audience segmentation. Our qualitative study hints at how productive a more quantitative analysis can be in capturing audience biases.

5.1.3 Assessing the "Local" Dimension in Online Climate Change Communication

In future studies, we suggest practitioners pay more attention to the 'local' dimension of the study. In our case, the website focused on global climate change and climate change at GNP. While local effects and consequences were mentioned, there was no focus on them. In addition, we did not define local in any specific way. These limited the "local" climate change results of our study. We believe the lack of attention to 'local' may explain our observation that concern for local level climate change was lower than concern for global or GNP (Fig. 2). Future studies, with a stronger definition and focus on local in both website design and survey questions may show different results.

5.1.4 Longitudinal Assessments

Since the logistics of our pilot study did not measure the long-term impact of exposure to online place attachment, we encourage future studies to do so. I.e., do the trends observed in the immediate post-survey persist through time? Ideally, a group of participants should be surveyed multiple times. In an academic setting, this might be at the start of the school year, then again, mid-term, and then again at the

end of the school year. The pedagogical value of such repeat testing is particularly useful, if as Corner et al. (2015a) describe, the learned information can be embedded into daily life through social environments that reinforce their importance. Our study's basic premise can thus be expanded to test how, and if, two comparable groups, one continually exposed to climate change literacy (for example, Environmental Studies majors) and one not (for example, Business majors) may respond over time to the surveys. Such studies add to understanding climate change communication pedagogy practices and whether place attachment promotes and maintains long term climate change concern.

5.1.5 Cognitive Studies on How Emotions and Rational Decisions Influence Climate Change Concern

Finally, we recommend that future studies also draw from the interdisciplinary scholarship that gauges cognitive and affective factors ("the numbers and nerves") of successful climate change communication (Slovic and Slovic 2015). Online place attachment websites (with their attention to identity, emotion, and dependence) provide ideal experimental spaces to test and measure how cognition (numbers) and affect (feelings or nerves) contribute to individuals' cultural values and risk perceptions of climate change.

5.2 Main Lessons

The results of this study support the hypothesis that place attachment can be employed to effectively communicate climate change online. We strategically designed a 2D website focused on GNP to engage place attachment. The statistically significant increase in concern about climate change at GNP, after viewing the website demonstrate the utility of this tool. For our audience of college students, viewing the website also closed the gap in concern about climate change based on gender, political affiliation, or educational track. Although comments from respondents suggest different levels of engagement with action related to climate change concern, the website was clearly successful in developing awareness of climate change. This study spotlights how online place attachment via such 2D websites present a relatively inexpensive way for climate scientists and others to communicate the importance of climate change, its effects, and adaptation and mitigation strategies. We recommend that future studies expand demographics and sample size, better define local parameters, and more intentionally integrate the Six Americas' strategies into the design of surveys used for analysis. Finally, we believe that such online place attachment websites (with their attention to identity, emotion, and dependence) provide researchers' with easy to design experimental settings to test the affective and cognitive components of climate communication.

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Understanding Communication Needs: A Marikina Barangay Experience Linking Flooding to Climate Change Communication

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1 Introduction

Effective adaptation to climate change requires translating the science into actionable information to support evidence-based policy and planning. However, climate change information can be a challenge to communicate and grasp. Cause and effect may be separate spatially and temporally, and some impacts may be subtle (e.g. gradual sea level rise, changing seasons) with trends manifesting over the span of decades or longer. Because climate, by definition, involves statistics, the public might misunderstand climate change science depending on how well they understand the nature of uncertainty (Lorenzoni et al. 2005; Weber and Stern 2011). The non-science public may have preconceived beliefs that hinder belief in climate change (Gifford 2011) or define climate change dangers differently (Lorenzoni et al. 2005). They may also base decisions on personal experience rather than, say, scientific projections (Weiler et al. 2012), or simply feel alienated from the issue (Leiserowitz 2006, 2007; Moser 2010). Even when people might understand climate change, they will not necessarily take immediate steps to mitigate or adapt to it (Whitmarsh et al. 2013). Conversely, people might support mitigation and adaptation measures by the government, but not understand the science behind climate change (Lorenzoni et al. 2005; Weber and Stern 2011). As a result, climate change communication practitioners recommend that communication messages should

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target specific audiences, such that people's norms, cultures, and emotions are directly addressed (Weber 2010). Further research, therefore, should examine community cultures, values, beliefs, and knowledge (Leiserowitz 2006, 2007; Whitmarsh et al. 2013).

In the Philippine context, climate change is often associated with disasters; hence, climate change adaptation (CCA) is embedded in disaster risk reduction and management (DRRM). The country is prone to tropical cycles and extreme rainfall events, which account for most of the country's major disasters (PAGASA and OML 2015). On average, about 19 tropical cyclones enter the Philippine Area of Responsibility, and while there does not seem to be an increase in the frequency of tropical cyclones, there appears to be a slight increase in the number of extreme tropical cyclones (150 kph and above maximum sustained winds) (PAGASA and OML 2015). Four of the 10 "deadliest" storms occurred in the past decade (Agence France-Presse 2014). The southwest monsoon also brings significant rainfall from June to September, sometimes enhanced by the presence of tropical cyclones (PAGASA and OML 2015), causing extreme flooding such as when Metro Manila was paralyzed in August 2012 and August 2013, and during Tropical Storm Ondoy (international name: Ketsana) in 2009.

Thus, climate change information is tied to flood risk communication. Extreme weather events are examples of hazards that might become more severe and/or more frequent with climate change. Examples of this linking between CCA and DRRM are replete in the media (for example: Yamsuan and Alave 2011; Vidal 2014; Worland 2015, among others), as well as key policy and planning documents. For example, Republic Act 9729, the Climate Change Act of 2009, states that "disaster risk reduction will enhance climate change adaptive capacity." Republic Act 10,121, the Philippine Disaster Risk Reduction and Management Act of 2010 recognizes existing and potential climate hazards and risks, and calls for mainstreaming disaster risk reduction and climate change measures into development processes. In the National Climate Change Action Plan (NCCAP), the strategic priority on Human Security (one of seven identified priorities) explicitly identifies the integration CCA and DRRM in communities and sectors across levels as an immediate outcome (CCC 2011). The NCCAP frames the linkages between CCA and DRRM and recognizes the need to exploit co-benefits and coordinated actions.

A 2013 survey by the Social Weather Station (SWS) in the Philippines revealed that 85% of the respondents felt that they personally experienced climate change in the last three years: 54% of these reported the experience to be "moderate" to "severe" (World Bank 2013). The then Vice-Chairperson of the Climate Change Commission linked this to the experience of extreme weather events. However, 52% have "only little" to "almost no" understanding of climate change and its impacts. Given this link between CCA and DRRM in the Philippine context, can flooding be used as a talking point, and as a means to make climate change more salient? The problem of flooding has been part of the Filipino experience even before climate change awareness became widespread. What lessons, therefore, can we from flood risk communication that can inform the challenge of climate change communication?

2 Flood Risk Communication

Researchers have explored perceptions of flood vulnerability, in addition to actual physical vulnerability. People who know more about their environment, have been affected by floods in the past, live in risky areas, and with low levels of trust in local authorities also tend to be more aware of flood risks (Scolobig et al. 2012). Being poor is not the only factor contributing to vulnerability; people of low socio-economic status were still prepared for flooding (Predo and Dargantes 2010; Zoleta-Nantes 2002).

Both Scottish (Werritty et al. 2007) and Vietnamese households (Razafindrabe et al. 2014) saw floods as acts of nature or God, although some Scottish participants also saw floods as products of issues in upstream land management. In contrast, participants from selected African countries claimed that poor drainage, bad city planning, overpopulation, and lack of consultation with the urban poor caused flooding (Douglas et al. 2008). English and Welsh flood victims were aware of the connections between climate change and flooding, but perceived the risks as low; some perceived they could be personally responsible for action (Bichard and Kazmierczak 2012).

Scottish households also wanted officials to knock on their doors, and for media messages to be addressed to them, in order to listen to warnings (Werritty et al. 2007). Strong local support networks also help communities prepare and even cope with floods better (Gaillard et al. 2008; Scolobig et al. 2012).

While researchers call for more community-based programs, advocacy, education, and infrastructure change (Douglas et al. 2008; Gaillard et al. 2008), there has still been little research on the culture that might contribute to how people understand flood vulnerability, and how they prefer to communicate about flood risk. Researchers might advocate for warnings and messages rooted in empirical research and using "simple language"; thus, flood risk communication becomes a matter of simplifying scientific information so that people will take action. However, this statement assumes that scientific information is needed and heeded; that awareness leads to actions; and that people will respond as assumed in a timely manner.

Are these "safe" assumptions? Is simple language enough to galvanize action? How do people understand these warnings? What might their attitudes toward flooding tell us about their possible attitude toward scientific information in general, and climate change in particular? What can conversations and perspectives of victims of flood tell us about how they view science, and how can these understandings of the audience lead us to stronger understandings of how to communicate climate change?

3 Study Site: Barangay Malanday, Marikina City

Marikina is a city in Metro Manila, the National Capital Region, with about 450,741 (PSA 2016) people over an area of 21.50 km^2 (Marikina City n.d.). It is a valley bounded on the east by the Sierra Madre mountain range, and on the west by the hills of Quezon City (Marikina City n.d.). Marikina was most affected by the flood waters of tropical storm Ondoy in 2009, which reached as high as the rooftops (NDCC n.d.).

The city is subdivided into 16 *barangays,* the smallest unit of local government. Barangay Malanday, with a population of 55,442 (PSA 2016) occupies 0.87 km^2 near the Marikina River. The flood hazard rating of western (near the river) and northern areas of the barangay is "high" (reaching 1.5 m) for 5-year floods while the central area ranges from low to medium for 25- and 100-year floods (DOST 2015).

The Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) is tasked with reporting the weather and sending out warnings about hazards, among others. There are two principal warning systems: those that describe rainfall (the color system of yellow, orange, and red, denoting increasing intensity and volume) and wind speed (the tropical cyclone signal system of numbers, denoting increasing wind speed). Both these warnings are disseminated in press releases that are sent to media channels, and are communicated in both English and appropriate local languages. Both these warnings are accompanied by gale and/or storm surge warnings, as well instructions for residents who live near mountainous areas, or fisher folk who might otherwise set out to sea on the day of a violent storm.

PAGASA updates are readily accessible through the media; the city DRRM council also cascades information to the barangays. The barangay governments further disseminate PAGASA warnings in their localities, even performing a "ronda": circling the barangay to make announcements with a megaphone or knock on doors as needed. Marikina also implements its own alarm system for the river water level: the first alarm (15 m) means cause for concern; second alarm (16 m) means residents should prepare to evacuate; and third alarm (17 m) calls for evacuation to designated centers. There is a fourth alarm (18 m) at which forced evacuation will be implemented for those who have not left their homes.

4 Study Methods

A focus group discussion (FGD) instrument was developed and pilot-tested to assess how stakeholders receive and perceive scientific information and other communication related to flooding hazards and risks. The instrument included questions on the participants' sources of information, message trust and credibility, causes of flooding, content of warning messages, and how the participants

understood flood warnings and concepts. The instrument also broke down information and activities for the periods before, during, and after flooding events.

Working with the university's service learning office and a local women's group, three groups of residents (5–7 members each) were recruited: those living in areas prone to floods often, those who lived in areas not as prone to floods, and college students. A facilitator convened each group separately, and all discussions took place in the barangay hall, a venue familiar to all the members of the group. All participants were asked to sign a consent form before participating in the discussion. All participants were allowed to answer the questions in the language of their choice.

A process documenter recorded and took notes during each discussion, and transcribed all discussions. The researchers analyzed the transcripts inductively, starting with keywords from the discussions which were used to build generalizations that would answer the research questions (Hatch 2002).

5 Results and Discussion

Findings clustered into four major themes, and are discussed here with support from verbatim passages from the FGDs. Participants are noted by a code containing their group designation (FGD 1, 2, and 3) and their placement in the group. F corresponds to the facilitator. All italicized text corresponds to passages translated from Tagalog.

5.1 People Have a Variety of Sources from Which to Draw Information, but Are not Particularly Motivated to Seek Out and Understand Science-Related Information

The participants trust mainstream media, especially TV and radio for older participants. Across the board, participants reported listening to and trusting their neighbors.

P11 *First, we are always focused on TV…Once the power goes out, we start buying batteries for our radio…and focus immediately on the radio.*

P26 *…some of us do not have TV. So I sometimes wait to hear something, or I watch TV at someone else's house.*

P23 *Of course you'll ask your friends: is this ok, this per kilometer measurement? Can my house take it? If it can't, then it's time to fortify your house (laughter) … Of course you'll listen to your friends.*

F *If you'll ask your friends, who exactly will you ask?*

P23 *First, here in the barangay…Because they have a lot of communication equipment, like radio…and they can call broadcasters.*

One participant in the 2nd FGD acknowledged that their neighbors could spread the wrong news and prevent other neighbors from responding properly to a storm. In this case, the participant said, one simply needed to be alert. Another participant in the same discussion said that she did not want to find out anything more about storms for as long as she knew her family was safe.

The young participants also relied on social media such as Facebook and Twitter, and news websites for information. This particular group was more passive in consuming information: they waited for information on what they needed to do, but would not necessarily actively search for information unless it was about something they thought they would need in their daily lives.

P37 *When I'm at home, I just listen. I don't have any energy to go out if it starts raining, so I just wait for my aunts to update me while they watch TV. Sometimes, I watch along with them. Or I use the computer. If you scroll, you'll see updates, and of course you'll be curious.*
P35 *Sometimes I get myself ready, and sometimes I look for information on the storm. My whole family knows about it before I even find out.*
F *So you're not the type to find out before your family does?* (P35 shakes head).
P35 *No–I'll just wait for the family.*

Members of the 3rd FGD also did not seriously consider information on storms because, they claimed, they were already "immune" and "used to" them.

F *So you mean to tell me…if you hear this information about a storm, you wouldn't be worried?*
P37 *No—I wouldn't care. (laughter)…It's all the same to me. We're used to it.*
P33 *We'll just wait for the alarm.*

The members also tended not to be interested in the science behind the weather.

P37 *…Why would we need to know about that if we won't use it in our daily lives? There are words that you don't need to really know the meaning of.*

Another participant admitted to not searching for more information because of school and work priorities, relying instead on friends and family for news.

These findings are supported by previous research showing the role of social networks in helping communities cope with risks and prepare for disasters (Gaillard et al. 2008; Scolobig et al. 2012), although it seems that in the Marikina case, strong social networks allow people to act on something because they trust their neighbors.

These findings show that the audience can use a wide variety of media channels to obtain information on science. Transposed to climate change communication, these findings show that older audiences will consult television and radio, while younger audiences will rely on social media. Moreover, these audiences will look for salient information on which to anchor the concept of climate change; in this case, the salience of a flooding event can make a good metaphor to help people understand the impacts of climate change.

5.2 People Want Information That Is Instructional, Exact, and Personal

The Philippines' typhoon warning system is replete with numbers, but the participants wanted information that they could relate to their everyday experiences. At the very least, they wanted information that was already familiar to them, instead of new warning systems.

P11 *I liked the signaling system better, yes.*
P12 *We don't use the other system that often. It's not familiar… to us.*
P11 *Ever since I was a kid, when I was young, all the way to today, I always hear about the signal…*
P14 Number one, number two.
P12 *The color coding is not familiar. We don't hear it that often.*

In some cases, the participants related the information to everyday experiences, correlating numbers and signals with analogies. These analogies made the information salient.

P23 (referring to wind speeds) *If you're living in a grass hut, the wind will blow it away. But if you live in a concrete house, then you won't feel it.*
P23 (referring to color coding warning system) *It's just like a stoplight. Stop if you see red.*

The participants wanted information that was exact and that they could act upon directly, without having to think or imagine what they needed to do next.

P11 *Our government needs to be alert on the time and day…Not just knowing that there's a storm, but they have to be ready, we have to be ready, but it is important that we know the date and time that the typhoon will come…*
P16 *What time it will arrive…how many days it will be here…they have to tell us about evacuation sites and what food they'll give to us…How they'll take care of us.*
P35 *…PAGASA needs to have weather forecasts on how strong the typhoon is, how much water is coming down, where it's hitting, where it will pass, what places will be affected.*

The members of the 3rd FGD, in particular, did not like hearing English-language broadcasts. The preference was not merely for the vernacular, but for useful content that was explicit and practical.

P35 *We'll just need to know about safety hazards, like what we might catch after a flood…*
P37 *And we need to know exactly where we need to go when the typhoon comes.*
P36 A*nd what time the floodwaters will recede so that we know when we can go home and clean our houses.*

P32 *They don't give us complete details…we want to know why we need to evacuate at all. (laughter).*

People also wanted communication and aid to be given directly to them. They had been helped personally in the past, and equated personal help to being loved by government.

P12 *It would feel really nice if you have something…for example, you might not need it, but if you're given something, then that would be really nice…it's like you're not alone…most of the time, we're jealous if someone else gets something.*
P11 *They need to go house to house.*
P12 *If you asked me, I'd say house to house. People will feel that you really love them. That's what's important…it's better if people go house to house so that we all feel loved…So that everyone knows about something…For example, if you want to tell us something, it's more automatic.*

In particular, participants in the 3rd focus group discussion wanted disaster preparedness seminars, and not merely disseminated materials.

P37 *They post something…they have a tarpaulin with information on what to do when there's a calamity, what you need to do when there's a fire…not everyone will stop to read. That's where [the government] is lacking. Maybe we need people to really attend disaster preparedness [seminars].*

Altogether, the participants want information that is specifically targeted to them and meets their needs. The findings match those in Scotland, where households favored officials knocking on their doors (Werritty et al. 2007). Findings indicate, however, that merely providing scientific concepts is not enough to encourage action. It appears that audiences want specific messages that provide concrete, explicit instructions rather than concepts that will make them have to think. Transposed to climate change communication, these findings indicate that specific, action-oriented messages (rather than purely conceptual information on climate science) would appeal to the audience more. The mode through which information is given would also need to be personalized, rather than through large scale events such as campaigns or brochures.

5.3 People Have Their Own Logic That They Use to Help Them Make Decisions

When asked about the causes of floods, people perceived that the floods were out of their control and due to a variety of reasons that had little or nothing to do with them. Some participants blamed the environment and even human nature for causing floods, but did not talk about their responsibility in preventing floods from happening.

P23 *It's because of climate change…like global–*
P21 *Global warming*
P23 *It's hard to answer that question because first, that's really nature…Right?… Maybe it's because people are sinful (laughs)*

The participants did not perceive that they had high floods in their own community, but thought that the water came from somewhere else and they simply were in the wrong place.

P21 *The thing is, even if we don't have a flood over here, but everyone elsewhere has deep floodwaters…*
P23 *The flood waters really come from the Sierra Madre (mountains)*

Interestingly, members of the 3rd FGD mentioned that the deep Ondoy floodwaters were due to dams being opened to release water. There are no dams in Marikina; rather, there are floodways that allow water from faraway dams to flow through the city and into major bodies of water.

P36 *The rain was really weak, and the floodwaters rose because I heard that they opened a dam.*
P33 *That's why it happened so quickly.*
P36 *That's why the flood waters were so high….*
P32 *…Ondoy didn't really carry a lot of rain or wind. What really caused the floods is the dams opening…Some people said we had three, four, five, six dams…We don't really know how many…But we know that during the time of Ondoy, a lot of people said that they opened a lot of dams.*

These rumors again point to a reliance on information from neighbors and friends. While the information is not necessarily true, some participants trust their neighbors and friends enough to make a decision on what they should do next. Moreover, participants consult observable reality in order to make decisions. Specifically, they watch the nearby Marikina River.

P26 *We're already ready. We wait by the creek, we go back every hour to check.*
P36 *We also check if the river is rising.*
P33 *I check Facebook. During the last flood, our floodwaters came up to my waist, and I'd sometimes go down to the river (laughs) to check if the water is still going up or already going down.*

Participants tend not to take warnings on television about impending rains or floods seriously if the weather that they experience does not match the broadcast.

P21 *We just hear it from TV…But we don't feel anything, no wind, no rain…And then they don't suspend classes, and that's when the rains are there…you can't say that everything they say on TV is perfect…we're just people, we also make mistakes…but sometimes the information really contradicts what we see.*

P25 *They tell us that we'll have a strong monsoon…So people of course start evacuating because they've already experienced Ondoy or Yolanda…And then suddenly, nothing happens.*

To some extent, this irritated participants, as though they expected the actual weather and predictions to match completely. This irritation also came from class suspensions that were unnecessary, and, conversely, class suspensions that were actually needed.

P34 *Sometimes they'll have believable information that a storm is coming…but there's no rain, no drizzling, and the sun's strong…For example, they'll show on TV that there's this so-and-so percentage of rain, but we don't get anything at all…*
P37 *…Sometimes they also announce that we don't have classes because of a storm, but most of the time, right, nothing happens? (laughter)*
P33 *We don't get any rain.*

However, because the participants relied heavily on experience rather than imagination, they often waited too long to act on information.

P14 *We just wait for the floodwaters to rise. We go to the river, check how high the water levels are…we leave if the floodwaters are already there*
P33 *Like during Ondoy…they'd leave when the water's right there*
P36 *That's the only time they'd leave*
P33 *Before that, we had very little rain*
P31 *Because even if the Barangay says we should evacuate, some people just don't*
P35 *They're hard headed*
P37 *They don't listen*
P31 *They really wait for an actual flood to happen*
P37 *They wait until the flood waters are inside their house, right? (laughter and cross talk) Oh, look, there's the water! It's time to go!*
P35 *Oh, it's true! There really is a flood!*

These findings are supported by literature on flood perceptions of other countries (Razafindrabe et al. 2014; Werrity et al. 2007). Scottish flood victims also saw floods as an act of God, but acknowledged that land management contributed to the problem (Werritty et al. 2007). This is in contrast to some of the participants in Bichard's and Kazmierczak's 2012 study, who saw that they had a personal responsibility in preventing floods in the wake of climate change. While some researchers might claim that better knowledge on the environment can lead to more risk awareness (Scolobig et al. 2012), it seems that more work is needed in actually making participants care about an issue enough to see that personal contributions to adaptation can lead to results.

In this study, Marikina residents want the information they receive to match evidence in the real world. Information on climate change must therefore be correlated to tangible, salient, real-world events that occur in the audience's context.

Further research might be needed to determine how to connect real world events to climate change adaptation, and how to encourage persons in this specific context to see their role in the environment.

5.4 People Have Other Criteria That They Use to Make Decisions

The participants in all focus groups spent the most time discussing evacuation as a key decision to be made during flooding. Related issues included discrepancies in relief goods distribution, as well as lack of space and food at evacuation centers. Participants wanted more information on clean evacuation centers and if there would be food and relief goods available. People waited to be told when to evacuate and wanted explicit instructions to do so, minus the numbers and color warnings.

P21 *And then you might dismiss the calls for evacuation…you might not believe them…and all of a sudden, it's really true, [the flood] is there*

Some participants also admitted to not evacuating because they wanted to save their things first. One participant admitted that flooding was bad enough for her to consider her purchasing decisions later on. It is interesting how relocation was not even mentioned until the facilitator brought it up.

P12 *We didn't know what to do with our things…it was that bad. So now, I tell myself… I don't think I want to buy new things anymore! (laughter)*

The participants wanted information on when they could go home and clean their houses. The participants also wanted more information on casualties, claiming that they wanted to know how they could help.

These findings are generally supported by the literature on flood risk perceptions in other countries, where people chose not to evacuate, despite threats to their safety, if they could not be near their source of livelihood. Transposed to climate change communication, the findings show that we cannot assume that all people will act as prescribed or assumed by dictated programs; stakeholders will need to be involved to ensure that proposed adaptation solutions match their priorities.

6 Conclusions and Implications

Climate change might be challenging to communicate, but much of the DRRM work already being done in the Philippines can be used as a springboard to discuss climate change, particularly in relation to extreme rainfall and flooding. The insights from this research invite future projects in climate change communication.

First, researchers should examine different stakeholders' understandings of what constitutes good science communication. Communicators need to be critical of the assumption scientific concepts and empirical evidence conveyed in a simple language will lead to desired action. Not all stakeholders have the same criteria for what constitutes useful and actionable information.

Second, researchers should understand the needs, preferences, and priorities of different audiences given their unique contexts. Those who craft climate change messages must consider local contexts and therefore use local images and events to make climate change and its impacts more salient. Those who work in climate change communication must also do research on their audiences and their respective priorities, such that communication materials and techniques address these contexts specifically. Such research might also allow climate change communicators to work closely with audiences in developing and sustaining long term solutions to climate change.

Third, researchers should explore further how to strike a balance between giving people what they want to know versus giving people what experts think they need to know. Building climate science literacy is important, but the content of training, education, awareness campaigns, and other capacity-building measures needs to be re-examined. Messages must contain concrete, what-to-do information balanced with essential scientific concepts, so as to avoid overwhelming and alienating the audience.

This study shows a need to examine audience perceptions and how these can contribute or take away from climate change action. These new findings add to the literature on social vulnerability and risk communication, both of which are complex and determined by local contexts. We recommend further studies on other locations in the Philippines, and encourage other researchers around the world to carry out their own country-specific research.

Climate change is an urgent issue for the world, but we need to carefully consider audience needs before plunging headlong into what might be costly (and due to haste, futile) climate change communication efforts.

Although drawing from flood risk communication can be helpful, there are also limitations to relying on the experience of extreme events as a springboard for climate change measures. Messages and actions will need to distinguish between climate change and climate variability. Indeed, it is important to build capacities to cope with the weather extremes experienced today, but it must be stressed that this will address only our current adaptation deficit. In the barangay example, measures for dealing with flood risk centered on evacuation and relief; respondents did not raise concern for longer-term measures such as relocation or city planning. Building resilience to potential future climate change will also entail considering the more gradual and subtle climate hazards (e.g. sea level rise, increasing temperatures) and mainstreaming long-term projections into development processes to encourage transformational change.

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Climate: The Great Maestro of Life on Earth. History, Didactics and Case Studies

Maria Rosário Bastos, Joana Gaspar de Freitas and João Pedro Cunha Ribeiro

1 Introduction

Climate change is a current issue nowadays. Scientific debates about this theme are rather common and the population in general is aware of the problem. These two words "climate change" seem to be everywhere.

But how well are humans aware? *Vox populi* says "weather isn't what it used to be"! People can feel the changes. But what changes? "Climate is recorded, weather experienced" (Ingold and Kurtilla 2000: 187), so people only have the perception of the meteorological events occurred during their life-time and probably they can only remember some, the ones that left a bigger impression. Weather changes are felt in daily or yearly basis. But climate? It is such a big picture. For instance, the idea of changes in the past is something vague associated with a distant Ice Age,

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now materialized and caricaturized in a Disney's cartoon. On the other hand, regarding the twenty-first century, there are all these gloom and doom speeches about catastrophic scenarios of collapse and extreme disasters. In these narratives humans seem to have scant chance of escaping to "the inevitability of a climate-shaped destiny" (Hulme 2011).

Discussions on climate change have been mainly focused in present and future contexts. Global warming in recent decades, sea mean level rise or the increase of extreme weather phenomena are often referred to. It is much less mentioned that climate has been evolving and varying over time. Instrumental measurement is only from the mid-nineteenth century, but scientific developments and the cross of different climate proxies, supported by historical data, are making possible the reconstruction of past climates with high confidence. To look into the past is an essential tool to better understand climate change and its challenges. The *long durée* allows a deeper perspective on subjects, a step ahead of short-scale visions (Guldi and Armitage 2014), showing how in different times and places humans faced weather inclemency by adapting, migrating or succumbing to it. Humans may be living something new, as McNeill says, because of the global dimension of problem, but locally this has been experienced before and there is a myriad of responses to nature's disasters, since dealing with these shocks have been part of the life of most generations until recently (McNeill 2008).

White wrote that historians are nearly invisible in discussions concerning climate change, because this is a new, controversial and highly technical theme and they do not feel comfortable with it. However, climate change is not really new and it is not an abstract science just concerning the atmosphere and greenhouses gases, it is a phenomenon with real impacts on people's lives and it is happening because of anthropogenic actions (White 2012). The challenge is to play out in different scales, unpack the problem into its components and then address the human part of it, which is "actually far more complex than the changing climate itself" (McNeill 2008; Kennel 2012; Braje 2016).

Having this in mind the authors set as a challenge to create a Climate History Course, in an Arts Faculty, in the context of History Graduation, open to students from all areas, with the purpose of giving them the tools to understand an issue that is in the spotlight in present times, but has been affecting humankind since her beginning, 2.8 million years ago. The idea was to create a forum to discussed concepts, like the Anthropocene, the different thesis about climate change, its connection to some key-moments in the history of human beings and the reasons that take countries to gather periodically to work out the future of the planet. Without having a special concern with a chronological order, the authors tried to cover the main historical periods, using case-studies as examples and integrating them in a global systemic view.

The aim of this chapter is therefore to talk about this experience and to show how historical examples can be used as tools to communicate climate change, vulnerability and resilience in a way that the general public can understand them. As Enfield (2014) puts it, experience and memory, cultural coping strategies and positive narratives are fundamental for the transformation of one's behavior

towards adaptation. The future is not written and it "will not be determined by climate, certainly not by climate alone" (Hulme 2011). It is possible that human creativity will create a different world and this has to be considered and discussed in the analysis and projections about future climate change impacts (Hulme 2011; Daly 2014). "In the end, it will all come down to public communication" (Kennel 2012). Decisions will be made based on governments and people understanding and the most important question will be "what will climate change mean for the people and the things I care about?" (Kennel 2012). This is where humanities and social sciences can make the difference.

2 History

Climate change always existed. Human societies have always had to deal with extreme weather events or with unpredictable changes in the expected weather at a given time of the year. Within their technical capabilities humans tried to face and overcome the challenges imposed by these variations. These coping strategies become embedded in human history herself.

The French historian Fernand Braudel compared climate to a "maestro", stating that since a remote past, observed in "slow motion", there is this bouncing factor—climate—influencing all matters of life on Earth. Geology allows to identify and map almost all its effects, but in general changes are the sum of almost imperceptible occurrences that only later are felt (Braudel 2001).

Going back in time, the evolution of the first humans is inseparable of the profound climate changes that the planet went through in the last million years. This seems indisputable, even if the causes that marked the appearance of some of their main features are still reason for heated discussions (Roberts et al. 2016). Having evolved from the higher primates that lived in Africa, at the end of the Cenozoic, the bipedal ancestors of the first humans are associated with the progressive expansion of the open savannah landscapes, as a result of the retreat of tropical forests.

It is often underlined that the accentuated dryness that subsequently took place in Africa with the installation of the glacial climate cycle, around 2.8 million years, match the systematic use of knapping tools (deMenocal 2011). This was a recoilless process that marked the appearance of the first humans and their dependence on technological development for survival. And if these early humans felt impelled later to disseminate through the African continent and to venture into the temperate zones of Eurasia, climate change probably ruled their advance and later may have led to their retreat.

It is also believed that the stress caused by aridity in the original cradle of humanity, around 1.8 million years, overlap the emergence of a production system of more sophisticated lithic materials, in particular, the manufacture of multifunctional bifacial volumetric tools: the handaxes. The use of these artifacts extended for more than 1.5 million years, following the dispersal of the first humans in the old world and the impact of more extended cold phases over 800,000 years.

The archaeological connection between the first humans and climate change is suggestive and it is used as an explanation for the later emergence of the

anatomically modern humans in Africa. Difficulties felt by local population, spread in different areas, contributed to the isolation of some groups in refuge areas where different genetic mutations, new behaviors or technological advances may have led to the appearance of modern humans (Stringer 2011). Also the persistence of Neanderthal populations in the Southern Iberian Peninsula can be justified by less expressive local climatic variations.

After the last glaciation there was an overall improvement of the weather conditions, associated with an increase in food resources, which can justify the significant raise of human populations. However, the extinction or migration of most of the large and medium-sized mammals that had populated much of Eurasia, as well as the significant development of the wooded areas, set new challenges to the survival of the local hunter-gatherers, forcing them to adopt new strategies. Some favorable geographical conditions associated with the presence of potentially domesticable animal and plant species, eventually gave rise to the first agricultural and pastoralist societies in large river valleys of the Middle and Far East. Water shortage forced these populations to organize themselves politically in order to create ingenious strategies for the management of available resources (Brooke 2014). The building and maintaining of irrigation canals networks were in the basis of the first city states and of the great empires of antiquity. Such empires had a turbulent political history, crossed by moments of splendor and decadence, wars, invasions and natural disasters, often reported in historical written sources (e.g. the Ten Plagues of Egypt). The epic stories of many of these empires, their achievements, betrayals or military defeats, also suggest they were frequently at the mercy of the four horsemen of the Apocalypse—pestilence, war, famine and death—, which announced the end of times. The image is so suggestive that Ian Morris (2010) proposed adding a fifth rider, representing climate change.

In fact, the crisis of the fourteenth and fifteenth centuries and its famous trilogy of famines, plagues and wars (and consequently deaths) coincide with the end of the Medieval Warm Period. During this, Europe saw the growing of empires, as the Franco-Germanic (Carolingian) one, the development of specific socio-economic patterns (feudalism), population increase and the Crusades. In the centuries that follow, the worsening of climatic conditions associated with the Little Ice Age may be in the basis, among other factors, of the Portuguese Expansion. The need of cereals and other resources have been pointed as one of the reasons that took the Portuguese to attack the north African city of Ceuta, in 1415. Some authors defended that "according to a current, neo-Marxist view, the Age of Exploration was a response to crisis conditions in Europe. By the fifteenth century feudalism was at the point of collapse. All the surplus possible has already being squeezed from the peasantry, the technological limits to the expansion of agricultural production had been reached, and the worsening climate of coming Little Ice Age was make a bad situation worse. Europe had to expand out of its geographical bounds" (Finney and Jones 1985).

For almost all human history climate has been omnipresent (Fig. 1). It still is, but something has changed in human-climate relation in the last two centuries. It is possible to discuss if human carbon footprint started in the Neolithic, with the

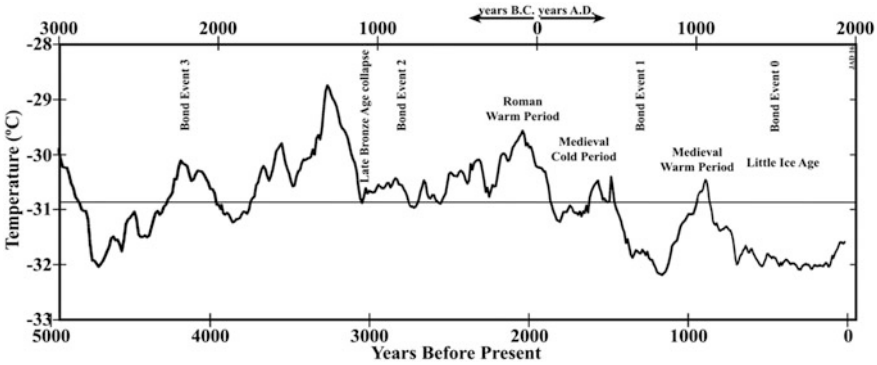

Fig. 1 Temperature evolution (Greenland's core) and historical periods in the past 5000 years BP. Adapted from Dias 2016

Industrial Revolution or with the Great Acceleration after the II World War. But it is indisputable now that anthropogenic actions changed climate and the world is changing because of that. However, in spite of the relevance of the subject and its impact on societies' present and future trajectories, Climate Change is rarely studied at Social Sciences and Humanities Schools.

3 Didactics

Feeling that the issue was missing (but it shouldn't be) from the *curricula*, the authors of this paper proposed to create and teach a course of Climate History in the 1st cycle of the History Graduation, at the Faculty of Arts and Humanities of the University of Lisbon. The course, taught by an archaeologist and two historians, focused on human's responses to previous climatic changes and extreme weather events. To avoid reducing the subject to a historical perspective and because interdisciplinarity is fundamental to the work developed, colleagues from other universities and research areas were invited to present their different approaches to climate. This way students had the opportunity to know how the issue is being tackled by geologists, chemists, climatologists and biologists.

This curricular unit worked for the first time in 2015–2016, in an optional basis. It enrolled 14 students from the courses of Archaeology, History and European Studies. Fourteen may not look much, but it is necessary to considerer that this course is a bold experience in social science and humanities *curricula*, being a challenge for both students and professors. During classes, the students revealed a considerable commitment and an active participation. This explains the good level of the final results and the authors expectations about the future of the course.

In the introduction to Climate Change, issues like how global warming was discovered and what are the most pressing concerns about the matter were analyzed

using videos and graphics (e.g. Leo Murray, *Wake Up. Freak Out—then get a grip*; Keeling's curve; the hockey stick graphic). Human's agency as a forcing mechanism of climate was approached through John McNeill's *There is Something New Under the Sun* (2000), Ruddiman (2005) and Brooke (2014). Their theories about the role of the twentieth century transformations, the Industrial Revolution and the Neolithic Revolution to anthropogenic climate change were discussed. Brooke's (2014) idea of a present "hybrid climate" was introduced and the concept of the Anthropocene was debated in the classroom. The exhibition "Welcome to the Anthropocene: the Earth in Our Hands", a joint production of the Deutsches Museum and the Rachel Carson Center, in Munich, was referred as an example of an attempt to portray the human footprint on the planet in its positive aspects, by linking the history of the Earth and humankind. The interview that Paul Crutzen gave to C. Schwagerl in 2013, available at the Environment & Society Portal, was given to students as a complementary reading. The expected climate change impacts—average temperatures increase, sea mean level rise, loss of biodiversity—and its economic, political and social consequences were also address. The last IPCC report (2014) was used as a support to show students the foreseen scenarios based in climate models. Portugal's situation deserved a particular reference. SIAM Project (Santos et al. 2001) data was detailed: predicted changes in climate, water resources, energy, coastal zones, agriculture, forests and human wealth were pinpoint. The "year without a summer" (1816) was employed to illustrate climate change impacts on societies. Tambora's eruption consequences on Europe and North America were talked (e.g. Luterbacher and Pfister 2015) and the specific case of the Iberian Peninsula was detailed (e.g. Trigo et al. 2009). Historical sources used in this last article were debated. The scarcity of cited texts—news and testimonies—was compared to the abundancy of information collected in a Canadian database dedicated to the issue (http://niche-canada.org/yearwithoutasummer/). The conclusion was that in Portugal there is still a lack of interest of historians for these matters. Possible sources and some new evidence were presented to the students (e.g. extracts from the newspaper *Gazeta de Lisboa*). The year without a summer presents a good "story" to explore the direct and indirect interactions between climate variability and humankind. Impacts on societies and "human agency identified in this example show the level of detail that will need to be achieved in our efforts to understand any potential future impact of regional climate change on humans and their responses to these challenges" (Luterbacher and Pfister 2015). Recent international efforts to reduce GHG emissions and to prepare the world to a new environmental set were also talked in classes. Paris COP21 (2015) was a good starting point to address the issue of the World Climate Conferences, its achievements and setbacks, along the years. After that, adaptation and mitigation measures were referred, the concepts were introduced to students and their global and local relevancy discussed.

Besides the main topics referred, some other big ideas where highlight in the classroom:

(1) Hulme (2012) wrote that Earth-system scientists have tried in the last decades to show that worldwide climate is changing using graphics of temperatures and CO2, satellite images of polar ice melting and computer-simulated models scenarios. But science concepts and artifacts are too abstract, too complex and too remote in time and space to interest people. After all, they are more concerned with their daily routines than with something they believe will happen in a distant future. There are more pressuring issues requesting attention (e.g. terrorism, economic crisis and poverty): climate change is still a vague problem. Also "doom-laden speeches of a scientific order, based on predictions and models that are practically unintelligible to the ordinary citizen" (Freitas and Dias 2015b) are not the best form of appealing to the urging need of shifting patterns.

(2) Climate is part of human history. To understand it a long-term approach is necessary: the past is a tool to fully realize present changes and perceive their exceptionality. To reconstruct past climate evolution proxies' data are used, but they can only show a part of the puzzle. Socio historical narratives are now being successfully employed as proxies to iterate and complete natural-systems information and to give a better perception of how previous communities and theirs associated environments were affected and deal with climate variability (Kaser 2012).

(3) That's not all, climate models are being pointed to ignore human agency. The hegemony of natural sciences—as Hulme (2011) puts it—in the issues concerning climate has reduced the future to "predicted virtual climates" in which communities have little to say. Since the values, cultures and practices of humanity are difficult to fit in mathematical models, societies' capacities for "evolving, adapting and innovating" have been neglected. "By emasculating the future of much of its social, cultural or political dynamism, climate reductionism" accentuates the idea of an over-determined future diminishing the range of possibilities that it may hold (Hulme 2011). This situation is already changing as the last IPCC (2014) report recognizes that human and natural systems are closely interlinked, but social, economic, and cultural factors "have been incompletely considered to date". Uncertainties about the response capacity of the socio-ecological mechanisms are a good reason to motivate the exploration "of a wide range socioeconomic futures in assessments of risk" (IPCC 2014: 11). As Carey (2014: 360) stresses human variables have to be integrated in climate change scenarios as well as historical data and trajectories. These trajectories include the disclosure of human adaptation and resilience experiences, as well as the cultural coping strategies that through time helped people to adjust and survive. Likewise, it is important to address and include the factors that influence human perception and behavior, especially the ones that contribute to the vulnerability or the resilience of societies (Endfield 2014: 307).

(4) In the end, because communication can be a step forward to socioeconomic and cultural patterns shifts, it is necessary to find a clear and compelling way of reaching a widespread public. Transforming what seems an abstraction into

tangible understanding can be done using historical examples. These are part of humankind's cultural heritage, for long they were the only form of storing and passing on collective knowledge. That's why, even today stories can still "be more enlightening and persuasive than any number of quantitative studies" (White 2012).

4 Case-Studies

Governments are said to be developing plans and policies that integrate climate-change considerations, a very difficult task because decision-making is based in the uncertainty of the expected phenomena without knowing their severity and timing. This imposes constrains to the allocation of resources and limits to the effective response capacity of the strategies to implement. The "complexity of adaptation actions across scales and contexts" means that experience and memory from previous situations can help societies to adjust and cope with changes (IPCC 2014). This is why historical examples are useful tools, they can provide good insights of communities' reactions to environmental transformations and at the same time offer a support to explain that climate variability and climate extremes happened in the past, may happen today and will happen in the future.

During the course historical examples were presented to students. Some of them were analyzed in detail, for instance: Sesimbra and the 1941 cyclone; and coastal erosion at Espinho and Furadouro. These cases have nothing to do with climate change, one is connected with an extreme event, the other to winter storms frequent in the coast of Portugal. Nevertheless, they are excellent examples to demonstrate how natural disasters affect people and how people develop cultural responses to deal with them (Mauch and Pfister 2009).

In February 15, 1941, Portugal was hit by a cyclone that caused important human and material losses. The most affected areas were coastal zones because they were exposed to strong winds and to storm surge, that caused overwashes, floodings and destruction. Sesimbra, a small fishing village south of Lisbon, was particularly touched by the disaster due to a conjunction of natural and social factors. The direction of the winds (S) and the orientation of the coast (E-W) where the village is located explain why Sesimbra was more hardly hit then other coastal areas. Most of its inhabitants were fishermen, and the storm destroyed their boats and gears, leaving them without means to provide for their families (Fig. 2).

The pre-existing poor social and economic conditions of this working group made it more vulnerable to this natural event since fishermen did not had financial resources to buy new tools. The destruction after the windstorm was followed by misery and hunger. Recuperation was only possible with the support of the community. A national public subscription gathered the necessary amount to construct new boats and rebuilt the damaged ones. The disaster gave more strength to Sesimbra's old claims of having a shelter port and better houses for the fishermen. Both requests were attended by the government until the end of the 1940s.

Fig. 2 Sesimbra after the cyclone, 1941. Photo from Arquivo Histórico da Câmara Municipal de Sesimbra

The renovated fleet and the technological development favored by the harbor improved fishing activities. The following years brought prosperity to Sesimbra. Those dark days are engraved in local memories, but they are also a symbol of the population's ability to survive as a collective organism. Within decades, the windstorm became a factor of cohesion to this community (Freitas and Dias 2015a).

The 1941 windstorm in Sesimbra is a historical example—a story—that can be used to pinpoint several issues easily apprehended by the general public: (1) natural disasters are nature's phenomena, but their impacts on societies depend not only of its severity, but also of human factors like exposure to risk and vulnerability; (2) vulnerability is influenced by many circumstances such as the local contexts (e.g. social and economic conditions, quality of infrastructures, health services), the response capacity of the institutions, the power to reconstruct and the ability to learn from the disaster; (3) the timing of disasters is not known, but communities may reduce their impacts by taking measures and be prepared; (4) previous episodes can show that extreme meteorological events are not something belonging to a distant future, they occurred in the past and can happen again in the present. Some of these episodes—like the one in Sesimbra—can be extrapolated to make people aware of dangers so that they understand that changes—adaptation and mitigation—have to be done.

Learning with disaster is the key-issue of the second case-study analyzed. Espinho and Furadouro are two coastal villages in the northwest coast of Portugal. Both have been experiencing severe coastal erosion problems since the nineteenth century. Part of their urban areas have been destroyed by the ocean causing considerable material damage. The history of these villages offers the perfect setting to talk about mean sea level rise, risks and the future of coastal zones. Like in Sesimbra case, Espinho and Furadouro open up the possibility to explore, within a concrete time and place, phenomena (e.g. extreme meteorological events and coastal erosion) that are said to be increasing as a consequence of climate change. More, they allow a thorough view of the reactions of the communities exposed to them, the solutions adopted and the long term effects of those strategies (the technological and the cultures ones).

The 1941 windstorm was a one-day event, but sea overwashes in Espinho and Furadouro occurred many times for more than a century. So is it possible to find patterns of learning and adapting from disaster repetition as Bankoff (2009) detected in the Philippines? The answer is not straight. Today, at national and local level, institutions are more prepared to act in the different phases (emergency, recovery and reconstruction) of a disaster. There can move in faster and with more material and human resources to help the victims and to support reconstruction. However, if adaptation is thought as a step forward toward sustainability the present situation of these villages is far from that. In fact, the strategy adopted to deal with coastal erosion in both places was based in the construction of engineering maritime works—groynes and seawalls—that were destroyed by the ocean in several occasions and rebuilt over and over along the years, growing bigger and more solid each time. Those engineering works had serious unattended side-effects: first, they extended coastal erosion to further areas along the coast; and, second, they provided a false sense of security to the populations, who believed they could live without risks close to the sea. So Espinho and Furadouro, once small temporary fishing villages, have grown into considerable (especially Espinho) seaside resorts, with much more people and infrastructures to lose to the sea. Coastal disasters in other parts of the world (e.g. Katrina, New Orleans, 2005; Xynthia, France, 2010; Sandy, USA, 2012) show that most people living near the ocean are not aware of the risks they face. Risk zero in the seaside is a delusion of the twentieth century (Sauzeau 2011) possible only because of the development of technology and engineering. The failure of these means in keeping human assets safe and the high costs associated with their maintenance raise the question of their sustainability in a long-term perspective, especially with the expected mean sea level rise. Espinho and Furadouro show that it is not necessary to wait for the future to have to decide what to do about coastal cities.

Cultural responses to climate crisis are the unknown part of the scenarios trying to disclose the world's trajectory, a path that is not written and is open to many possibilities. Climate models point to many future negative impacts, some of them quite catastrophic. But this is not a closed issue and some people believe that if climate is changing, humans will change accordingly, just as they did before. Behringer (2015) tries to show this in his cultural history of climate giving several

examples. For him computer models are built according to the given information, which is partial, they reveal that is expected, not what is going to happen. Carey (2014) and Hulme (2011) are also very critical: in their opinion models' analysis take societies as passive or static elements. Hulme (2011) stresses that the ability to change cultural norms and practices and the "creative potential of the human imagination" are being ignored. McNeill (2000) is not so optimistic, based in his experience of the twentieth century transformations and the way societies sacrificed natural resources to maximize their profits. Even so this historian thinks that studying the past can provide the right information to choose and prepare the possible futures, in order to avoid the worse scenarios. For Smith (2011) the question to be asked about the future is not about numbers (e.g. people *versus* resources), but about what kind of world humans want to live in. He wrote that people' choices determine actions and actions change the course of History. So how can we influence choices and start changing things?

5 Conclusions

In addressing climate change two paths to sustainability may be considered. First, though the development of new technology that allows countries to do the transition to low-carbon economies and to reduce GHG in the atmosphere using more effective methods for carbon storing. Second, by modifying societies' habits, cultures and life-styles to diminish fossil fuel consumption and also to implement the adaptation and mitigation measures that will help humans to survive another environmental crisis.

The second path is the one where Social Sciences and Humanities can have a relevant role. The authors believe that one way is to prepare the present generation of students—specially the social sciences ones that are not so aware of these issues—to participate in the discussions and be able to reinforce interdisciplinary groups (in academia or outside her) working to find global solutions.

Society is the key to global change. Sustainable governance depends on the awareness—both by the public and the authorities—that humans have to learn to live with a changing environment. Science can provide technical solutions for adaptation and mitigation, but it must be societies to implement them and this is a complex process. People are asked to prepare for something too vague that will happen no one knows where or when. Historical examples turn an abstraction into a concrete event, they can provide the right background to discuss future challenges, by talking about real human beings and establishing a context within a precise time and place. The closest the examples go from people's reality the easiest they perceive it could happen to them.

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Children Communicating on Climate Change: The Case of a Summer Camp at a Greek Island

Constantina Skanavis and Aristea Kounani

1 Introduction

Climate change (CC) is an overarching theme in the scientific, social, political and economic arena. As such, its study involves many disciplines, each addressing the issue from its own point of view. The communication of an issue of this complexity is therefore complex by definition (Aguila Coghlan 2011).

Ecological literacy can become a crucial step towards creating personal perspectives, critical analysis and prediction skills. Environmentally literate individuals would have basic and deep scientific backgrounds, converting their acquired knowledge into action with increased levels of environmental values, attitudes and skills (Ertekin and Yuksel 2014). Traditional reforms targeted science knowledge via in-class activities, through which the students were rarely induced into changing their attitudes and behaviors about the environment (Mahadeva 1989). Out-of-school experiences that supplement in-class curricula increase the capacity for affective development (Stone and Glascott 1998). Summer programs, for example, provide an ideal opportunity for environmental education in an interactive context (Larson 2008). To provide successful awareness solving skills for emerging problems, developing and integrating environmental perception in children at an early age must be a priority (Ertekin and Yuksel 2014).

Summer programs represent an important vehicle for environmental education, but their impact is often overlooked (Larson 2008). The present study contributes to the literature wealth by exploring the effects of nature-based summer camps, with intentional environmental education programming, while attempting to measure

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children's environmental consciousness. More specifically, it examined how campers at an environmental summer camp in Greece, at the island of Skyros, were evaluated on their climate change knowledge, attitudes and behavior. Also this study assessed the value of a summer camp as an environmental education tool on communicating issues of concern.

2 Climate Change Communication

Climate change communication is no longer the largely uncharted topic of 10 years ago (Moser 2016). Communication has become an integral part of the climate change discourse as scientists, governments and civil society organizations have recognized the crucial role of an effective communication in raising awareness about the consequences of climate change on life (Harris 2014). Although, climate change is perceived as an important and sensitive issue many people still do not behave in a sustainable fashion (Energy Saving Trust 2007). One potential reason for this inaction is that the climate change is a psychologically distant concept and therefore the benefits of acting do not seem urgent (Rayner and Malone 1997). Furthermore, the focus upon the negative related consequences is not always the most effective communication approach (Spence and Pidgeon 2010).

Among the identified obstacles, the complex nature of the CC issue has been reported, as well as the media coverage difficulties (framing, agenda setting etc.) and the influence of the public support or opposition groups (Aguila Coghlan 2011). The uncertainty of climate science has become a prominent issue in the public eye. Ubiquity attached to the climate change message is likely to have important consequences for individuals' thoughts and behavior on the issue of concern. Not knowing what the future might bring sometimes leads people to be cautious and to act in protective ways for their property and belongings (e.g., through taking insurance) (Morton et al. 2011).

Most environmental campaigns related to climate change are based on the principle that people need more information to behave pro-environmentally. However, this approach in terms of "information-deficit" has been widely criticized as being inadequate to promote behavioral change (Kellstedt et al. 2008; Ockwell et al. 2009; Schultz 2002). Social psychology could be useful in suggesting tools to promote pro-environmental attitudes and behavior (Parant et al. 2016). Communication about CC should aim to achieve meaningful engagement in all three facets: understanding, emotion, and behavior (Ockwell et al. 2009). Effective communication can improve people's knowledge of how their actions contribute to global warming and the impact it has on their livelihoods, health and cultural heritage. Environmental education programs actively engage citizens to find sustainable solutions by participating in mitigation and adaptation (Harris 2014). The sensitivity allured by the message is also likely to impact how participants respond to a communication. There is a growing literature on the impacts of fear framing,

emphasizing the threat content of a mess in order to provoke a more extreme emotional response (Wilson et al. 1988; Spence and Pidgeon 2010).

3 Communicating CC to Youth

Climate change is an issue that also puzzles children (Leal Filho 2009). Hundreds of children around the world at some point of their lives have risk from environmental hazards. Climate change, has often been called, the 'greatest crisis for children's health' (Waterston 2006; Strazdins and Skeat 2011). This stems from children's potentially greater duration of exposure, their greater sensitivity to exposures and because of their dependence on care givers for appropriate preparedness and response. Because of the vulnerability to climate changes, education programs should prepare children for future risks (Ebi and Paulson 2007).

It is important to acknowledge that there are some barriers seen when someone tries to communicate on the climate change issue, especially to children (Strazdins and Skeat 2011). One of such barriers is related to some misconceptions of what climate change in fact is. If not adequately addressed, children might adapt a pessimist view for climate change or the wrong assumption of what it means (Leal Filho 2009). For many children climate change may cause additional stress. Lack of control over their environment is a source of particular stress for many children, leading to a sense of existential despair (Strazdins and Skeat 2011).

On the other hand, in CC communication the role of educators who communicate the issue to children is of extreme importance. Communicating the risks of climate change encourages preparedness and ensures increased safety probability in a situation of a potential disaster. Moreover, teachers need to be aware of the appropriate level of knowledge that should be introduced on climate change issues in order to address misconceptions and uncertainties (Boon 2014).

4 Outdoor Environmental Education

Though today's youth and children are technologically adept, they are getting more distant from nature. Their image of human-nature interaction is more often based on television documentaries and other media images (Palmer 1998). Out of school experiences are therefore important (Trexler 2000). Teaching and learning using more traditional indoors' forms of education, have other values and qualities than those that take place outside the classroom and the school building (Smeds et al. 2011). Nature-based outdoor education programs are effectively improving environmental awareness and sensitivity (Okur-Berberoglu et al. 2014; Apostolopoulou et al. 2016). Many centers offering summer camp programs in outdoor settings are based on tailored to the participants' environmental education needs (Boon 2014).

5 Summer Camps

The camp experience has always been associated with learning and human development, which often takes place in a pleasant informal outdoor type of experience and has a holistic, child-centered approach (Bialeschki et al. 2016).

Today's philosophy suggests that all youth is at risk, since high rates of boredom, alienation, and disconnect from meaningful challenges and activities result in a deficiency of positive development (Larson 2000; Hederson et al. 2005). The focus is not on the problems of youth but on the ways that community resources can be developed to help young people grow into a successful adulthood (Hederson et al. 2005).

Although many people believe that parents are responsible for positive youth development, parents have depended on community offered non-school experiences, such as the camps. Most camp programs are considered to be part of a positive youth developmental movement, aiming to offer experiences that are not only safe and enjoyable but also facilitate children's progress towards adulthood (Hederson et al. 2007). The summer camps could be described as a process of participation, where individuals are empowered to follow their interests, while exploring nature and question human interaction (Bergman 2014).

On the other hand summer environmental education programs expose children to unfamiliar environmental setups and concepts in an exciting context, which may induce interesting attitude alterations (Larson 2008). Therefore, nature camps might be more efficacious in promoting children's emotional affinity to nature, ecological beliefs and environmental behaviors than in-class environmental education programs (Collado et al. 2013). Understanding and cultivating children's environmental consciousness may be crucial to rectifying the environmental degradation and to mitigating the impacts of climate change (White 2004; Garner et al. 2015).

6 Environmental Education in Greece

In Greece the Environmental Education (EE) mainly is provided through its' formal school system. Additionally, in Greek schools the environmental issues are dispersed in the outline of almost all the subjects taught into the school system and the related EE extent is larger than what is seen in most of the other states of the European Union (Michaelides 2005). Nevertheless, formal environmental education still hasn't fully reached the ultimate goal of a responsible environmental behavior of the participating students. Environmental attitudes, behavior and values are influenced by environmental education, although the extend of the EE's impact has not been found to be in a proportional relation (Larson 2008).

7 Case Study: Project Skyros 2016

In summer of 2015, an environmental awareness campaign program was delivered at the island of Skyros in Greece. This program was designed and administered by the Research Centre of Environmental Education and Communication, of the Department of Environment at the University of the Aegean. During its first year of operation, an environmental camp for children was offered to the local community children as well as the ones visiting the island. The project was known as SKYROS 2015 and it was repeated this summer as a SKYROS 2016 project (Apostolopoulou et al. 2016). The objectives of this summer environmental camp at Skyros Island were related to the dissemination of environmental education to children and to the promotion of their responsible environmental behavior through theory and hands on experience in an outdoors set up. The camp was structured in a way where participants were introduced through fun type of experiences to the environmental protection and restoration aspects of their local community through a global understanding of selected environmental issues.

7.1 Environmental Summer Camp at Skyros Island

Based on a well-prepared schedule, children were confronted with various regional and global environmental issues, such as food chain, biodiversity concerns, water cycle, water pollution, air pollution, greenhouse effect, climate change, global warming, forest fires, natural disasters, floods, droughts, renewable energy, recycling, earthquakes, litter, non-renewable energy, endangered species, etc. Specifically, during the 2nd and 3rd week they were confronted with the topic of climate change, the causes and the impacts of this major global issue, and action that participants should take in order to be environmentally active.

8 Methodology

8.1 Research Area

The geographic area of the research implementation was the island of Skyros, and specifically the port of Linaria. The small tourist port of Linaria is considered a model port and one with high tourist interest generation. In the last ten years, it has received lots of national attention and it is presented as the most complete and friendly public port in Greece, with tourist arrivals, showing an increase of 479% (Antonopoulos et al. 2015) The port of Linaria has adopted a way of sustainable management of its environmental impact, without spending lot of its limited financial resources (Antonopoulos et al. 2015; Kuznetsov et al. 2015).

8.2 Research Sample

The research sample was composed of children, aged 6–14 years old (53% at 6 to 8 years old, 32% at 9–11 years old and 15% at 12–14 years old). The total number of the participants was 19; the 74% of them were girls and 26% were boys. The 86% of the participants had been to an environmental summer camp at least one more time, while the 14% had no camp experience.

8.3 Research Instruments

The data were collected through personal interviews, which were held at the beginning and at the end of the camp season. Two questionnaires were developed in order to address and assess the children's understanding of the climate change issue before and after the camp's intervention. The participants' attitudes and environmental behavior were evaluated as well.

Questionnaire number one was composed of 41 questions, which were selected after an extensive literature search (Abdel-Monem et al. 2014; Lynn and Longhi 2011; Loureiro et al. 2012). The first 4 questions inquired demographics' information (e.g. gender, age, educational class). The next 18 questions assessed knowledge on the topic of climate change and the related topics of global warming, greenhouse effect, impacts of climate change etc. Subsequently, the next 12 questions assessed children' s attitude on climate change and the last 7 questions gave data about their environmental behavior and their willingness to participate in activities related to CC.

The second questionnaire consisted of 50 questions (Abdel-Monem et al. 2014; Lynn and Longhi 2011; Loureiro et al. 2012), with a significant percent of them being similar to the ones in questionnaire number one in order to assess respondents' consistency. The first 4 questions of the latter questionnaire, were also about demographics' information (e.g. gender, age, educational class). The next 17 questions assessed the changes on children's knowledge on climate change and the related issues such as global warming, greenhouse phenomenon, air pollution etc., after their two weeks participation in the summer camp. The following 16 questions evaluated the changes on their attitudes. The last 12 questions assessed alterations on children's environmental behavior and participatory tendency.

Environmental education methods used during camp environmental instruction were lecture, brainstorming, simulation and modeling, outdoor education, field study, environmental walks and field games.

9 Results

9.1 Pre Camp Results (Based on First Questionnaire)

9.1.1 Knowledge

All of the campers said that at their school they were taught about several prominent environmental issues. The 26% of the respondents knew what CC is, the 21% slightly knew about it and the majority of them (53%) answered that they didn't know a thing.

When they were asked if they knew what causes "the greenhouse effect" and what would happen if the Earth continued to warm up, they responded as shown in Figs. 1 and 2, correspondingly.

Finally, the interviewees were asked a group of questions asking them to tell what is right or wrong with some commentaries about climate change. The results are presented at Table 1.

9.1.2 Attitudes

All the participants said that they were happy every time they did something environmentally friendly. Most of them did not live far from school (37% lived less than 1 km away and 32% from 1–5 km away), while the 32% lived a distance of

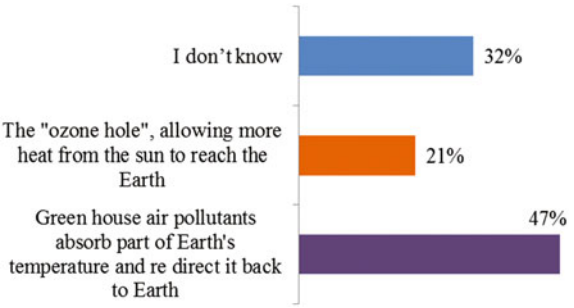


Fig. 1 Participants' knowledge about what causes the "greenhouse effect"

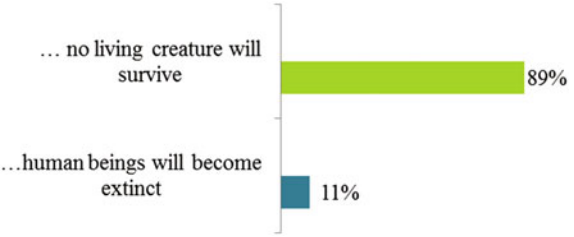


Fig. 2 Participants' knowledge about what would happen if Earth continued warming

Table 1 Campers' knowledge on commentaries about climate change (what is right or wrong)

Commentary	Right (%)	Wrong (%)
Our planet is a big greenhouse, since there are many growing plants on it. So, we usually say that the "greenhouse effect" occurs on Earth	68	32
Air pollutants concentrating on surface of earth cause temperature elevation	74	26
Global CC causes floods and droughts to various regions of Earth	84	16
Global CC causes health problems to humans	84	16
By recycling we save energy. Therefore we reduce climate change potential	74	26

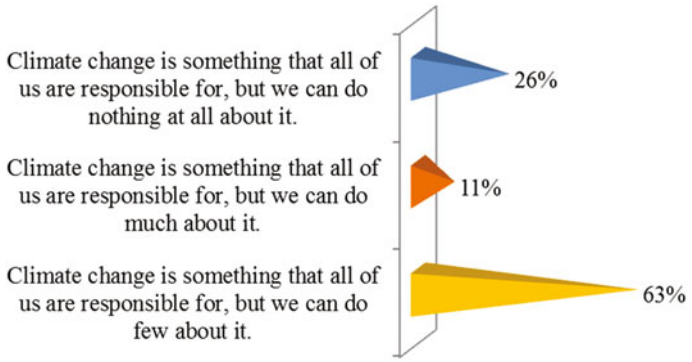


Fig. 3 Participants' beliefs about climate change

5–10 km away. But only a percentage of 32 went to school on foot, whilst the 37% went to school by car or motorcycle and a 32% by bus.

Figure 3 presents how they responded when they were asked to state what they believed climate change is.

Figure 4 presents the participant's responses when they were asked to express their beliefs about the acts that they could do individually to reduce the climate change.

9.1.3 Behavior

The last group of questions attempted to identify the interviewees' participating behavior or willingness to get involved in climate change actions. So, they were asked whether or not they had ever participated with their friends to an effort to convince adults for issues related to climate change, and a 58% said that they had, while the 42% said they hadn't.

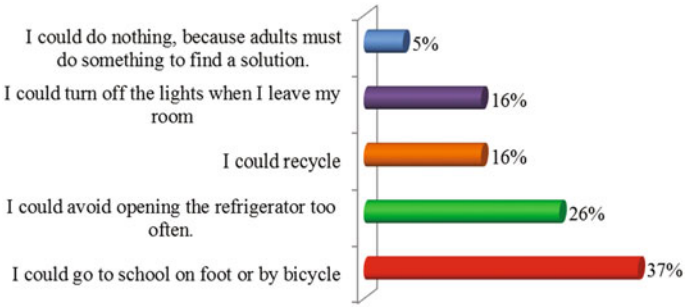


Fig. 4 Campers' beliefs about what they could do individually to reduce the impacts of climate change

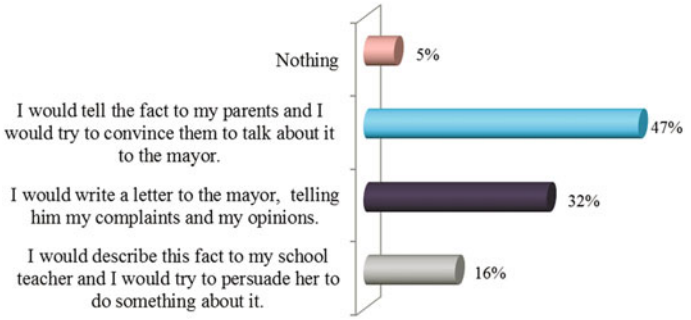


Fig. 5 What campers would do if they found out a case of air pollution

The next question was about telling what they would have done had they had seen someone to pollute the air, e.g. a factory. The related results are shown in Fig. 5.

A sixty three percent of participants stated that they had never participated to an activity to mitigate the impacts of climate change. Additionally, they were asked whether or not there was an environmental group in their school and most of them (89%) responded that there wasn't one. From the 11% that had an environmental group in their school, half were members of that group. From those who answered that in their school, there wasn't an environmental group, the 79% said that they would try to convince their teacher to create one, while the 10% wouldn't.

9.2 *Post Camp Results*

After the end of the summer camp all the campers were asked to express their feelings about their experience to this specific environmental summer camp and all of them said that they enjoyed their participation and they surely would like to repeat it.

9.2.1 Knowledge About the Issue of Climate Change

Starting the post camp interview the participants were asked if they thought that their knowledge on environmental issues had increased after their camp participation. All of them said that it surely did. Then, they were asked if they knew what the climate change was. A percentage of 56 said that they knew and a percentage of 44 said that they knew a few things. The next question was about how the campers learnt about the climate change issue. The answers are shown in Fig. 6.

Next the participants were asked what the causes of "the greenhouse effect" were and what would happen if the Earth continued warming up. The results of their answers are shown in Figs. 7 and 8, correspondingly.

Finally, the campers were asked to tell what is right or wrong with some commentaries about climate change. The results are presented at Table 2.

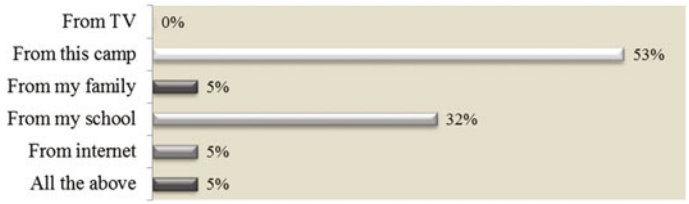
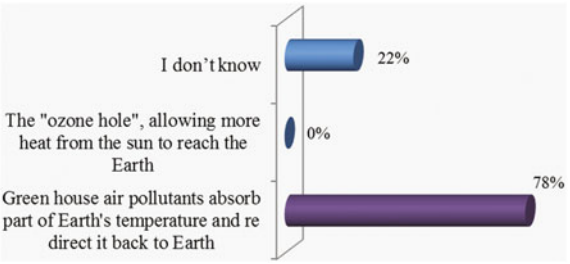


Fig. 6 How the campers got informed about the climate change issue

Fig. 7 Participants' knowledge about what cause the "greenhouse effect"



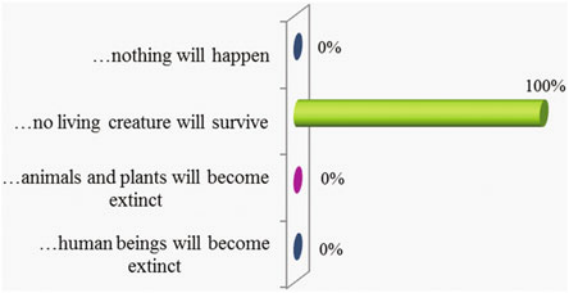


Fig. 8 Participants' knowledge about what would happen if Earth continues warming

Table 2 Campers' knowledge on commentaries about climate change (what is right or wrong)

Comments	Right (%)	Wrong (%)
Our planet is a big greenhouse, since there are many growing plants on it. So, we usually say that the "greenhouse effect" occurs on Earth	44	54
Air pollutants concentrating on surface of earth cause temperature elevation	100	0
Global CC causes floods and droughts to some different regions of Earth	89	11
Global CC causes health problems to humans	89	11
By recycling we save energy. Therefore we reduce the gases that cause climate change	89	11

9.2.2 Attitude About the Issue of Climate Change

From those campers who had said that they went to school by car, motorcycle and bus (69%), a percentage of 60 said after the participation to the environmental summer camp they would try to convince their parents to let them go by bicycle or on foot and only a percentage of 9 said that they wouldn't.

Subsequently, the children were asked if they believed that climate change really occurs and what they believed climate change is. Their answers are presented at Figs. 9 and 10.

Also they were asked to express their beliefs about the actions that they could take individually to reduce the climate change (Fig. 11).

9.2.3 Participating Behavior Regarding the Issue of Climate Change

Finally the campers were asked some questions in order to record the changes on their participating behavior or willingness to get involved in climate change actions. From those who had answered that they had never participated to an effort to

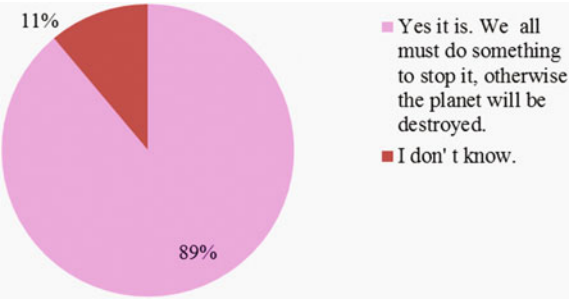


Fig. 9 Participants beliefs whether or not climate change does occur

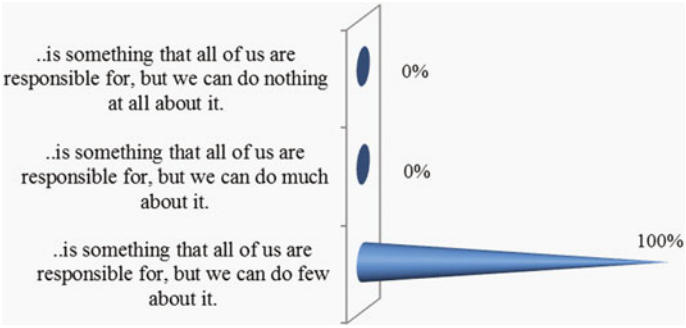


Fig. 10 Participants' beliefs about what is climate change

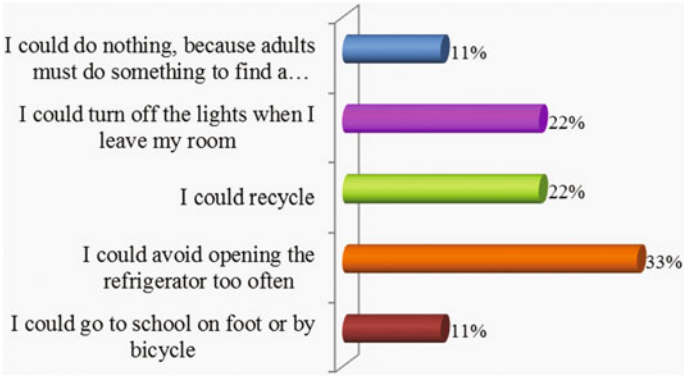


Fig. 11 Campers' beliefs about what they could do individually to reduce the impacts of climate change

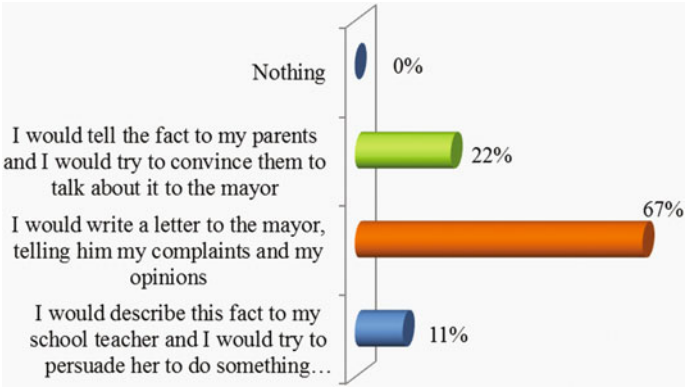


Fig. 12 What campers would do if they found out a case of air pollution

convince adults for issues related to climate change (42%), they altered their conduct and had the willingness to do so from now on.

Subsequently, they were asked to tell what they would have done if they had seen someone to pollute the air, e.g. a factory, and the results of their answers are shown in Fig. 12.

Moreover, all of the interviewees who said at the pre camp interview that they had never participated to an activity related to climate change reduction or prevention (63%), said that they would participate from now on. Additionally, all of the campers who didn't have an ecological group at their school (89%) would try to convince their schoolteacher to create one, as well as they would try to convince their teacher to create an ecological school newspaper related to climate change, although they knew that they would have to devote time from their free time.

10 Discussion

Certainly summer camp is rarely an aversive experience for children, nor is it an experience reliably associated with significant negative change (Thurber et al. 2007). This fact is demonstrated in this study by the children's willingness to participate on an environmental summer camp again. Their interests, abilities, and developmental needs may have been generously matched to this particular camp.

Obviously, a positive effect is observed on children's knowledge, attitudes and participation behavior on the issue of climate change, after their environmental summer camp completion.

10.1 Knowledge About the Issue of Climate Change

As the pre camp results showed, children mostly learn things about the environment from their school. Their families did not seem to play a crucial role on their environmental education, as only a percentage of 5 had learned about the issue of climate change, through the discussions with their parent. Although it is believed that parents are responsible for positive youth and children development (Hederson et al. 2007) and substantially for their kids' environmental responsible behavior, the parents of the participants did not deal with the issue of climate change seriously enough in order to increase their kids' environmental literacy.

As Boon (2014) has noticed, the teacher's role is of paramount importance to support sustainable development. In addition to this in order to address misconceptions, misunderstandings and uncertainties about climate change, educators must be able to increase the level of knowledge of school children. In this case study, there were misconceptions and misunderstandings to the related issues on climate change, as it is shown in Table 1. This leads us to suspect that lack of experienced educators on the climate change issue is responsible for this situation. After their participation to the environmental summer camp, children were experiencing an increase on their CC knowledge. Simultaneously, it is observed a decrease on CC misunderstandings. Moreover, a comparison between Tables 1 and 2 proves the positive impact of this summer camp on children's knowledge.

10.2 Attitude About the Issue of Climate Change

Children had a moderate environmentally friendly attitude before participating to the environmental camp. Nevertheless, they appeared to be more environmentally friendly after their participation in the camp, since they showed an increased motivation to make some changes on daily basis. So, all of them who lived close by to school would try to convince their parents to let them go to school on foot or by bicycle. Also, as the results in Figs. 9 and 10 showed there is a contrast on their CC beliefs. On the one hand in Fig. 9 the participants said that climate change occurred and all humans must do something to stop it, in order to diverse its impacts. On the other hand in Fig. 10 they appeared to think that although humans are responsible about CC they could do few things to diverse it. As Nicolson-Cole claimed (2005) this misconception is due to wrong communicating messages, which desensitize children giving them the impression that they are powerless into contribute to the reduction of the impacts of climate change.

10.3 Participating Behavior

Younger age groups typically are more pro-environmental (Jones and Dunlap 1992; Van Liere and Dunlap 1980). Middle childhood develop an emotional attachment to the environment (Larson 2008). This fact was also identified at this environmental summer camp at Skyros Island. As the results of pre and post camp interviews showed, all of the children were happy doing things to preserve the environment.

A number of studies have addressed gender differences in environmental participation orientations. Research suggests that females are more inclined to support preservation of nature and are more likely to show support for EE (Fernandez-Manzanal et al. 2007; Larson 2008). This actually was identified in this survey too, as the majority of interested to participate in an EE summer camp were girls (74%).

Participating in nature-based summer camps raises familiarity with nature, increase environmental knowledge, awareness and behavior on environmental issues, such as climate change (Dresner and Gill 1994; Garner et al. 2015). This fact is certified largely in this case study. There was a positive change at children's participating behavior, as those campers who said that they had never participated in efforts to convince adults about the climate change issue (42%), after the summer camp all of them had the willingness to participate from now on. Additionally, comparing the results of Figs. 5 and 12, is observed an increase to willingness to be more environmentally active. They even stated that they would send a letter to the Mayor complaining about a potential case of pollution in their hometown. They also stated that they would participate in actions to reduce climate change, they would try to convince their teachers to create an ecological group and a newspaper related to climate change, willing to even sacrifice their free time.

11 Conclusions

As Bergman noticed (2014) an environmental camp can count as a success educating, empowering and even radicalizing both its participants and others in the broader environmental movement. This can be seen as transforming people from passive bystanders to citizen activists, which some see as the key to effecting the systemic changes needed for radical emissions reduction. A well-structured and organized summer environmental program, such as this one at Skyros Island, which is staffed with experienced environmental educators, could be a key in communicating climate change, specifically to children. The results of this research may affect the design and scope of future EE programs, especially those focused on future generations. Environmental education programs that promote positive interactions with nature strengthen children's eco-affinity and may incite a deeper appreciation of the natural world (Larson 2008).

It would appear that there is a gap in the communication of climate change science among the respondents interviewed. It is noted that these respondents were largely based in rural Greece; differences may emerge should the survey be replicated in metropolitan areas. Based on research like this one it cannot be determined whether educators can be viewed as credible sources of climate change science and whether the provision of information about climate change science to school children can influence the views of the parents and other adults in the broader community (Boon 2014). There is no doubt that this case study enforces the fact that we need to boost our educational levels around the year in order to assure all citizen are given the opportunity to participate actively in the environmental decision making. And there is no better time than when we are young!

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Communicating the IPCC: Challenges and Opportunities

Jonathan Lynn

1 Introduction

The Paris Agreement on climate change adopted at the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris in December 2015 can be seen as an endorsement of the communications activities of the Intergovernmental Panel on Climate Change (IPCC). The agreement is science-based and draws on the findings of the Climate Panel in its Fifth Assessment Report (AR5) (IPCC 2014a). The Agreement and associated Decision (UNFCCC 2015) both call for an important role for the Climate Panel in the continuing work, with future IPCC inputs seen as a key input into the global stocktake. And yet between finalization of the report in 2014 and the conclusion of the agreement, the IPCC has been criticized by stakeholders, including its prime audience of policymakers, for delivering products that are difficult for non-specialists to understand and use. This criticism can best be summarized by the call of the then Executive Secretary of the UNFCCC, Christiana Figueres, for the

The author is writing in his personal capacity, and the views expressed do not necessarily reflect those of the IPCC.

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Climate Panel to move beyond its flagship Summary for Policymakers (SPM) and consider a "Summary for the Citizens of the World" at the opening plenary of the 41st Session of the Panel in February 2015 (IISD 2015). Indeed, it has been argued that the SPMs have become progressively harder to understand over the years and are less readable than a paper by Einstein (Barkemeyer et al. 2015).

As the IPCC embarks on a new cycle of reports—the main Sixth Assessment Report (AR6) to be finalized by 2022 and three special reports[1] to be delivered in 2018 and 2019—these calls for greater accessibility continue, posing challenges for the Climate Panel. Climate change is literally an issue that affects everyone, and a wide range of people now has an interest in the findings of the IPCC. The public now expects institutions to be open and responsive (Karjalainen et al. 2014). Rapidly changing technology (and a rapidly changing media environment) offer new possibilities for disseminating information. And yet the subject matter treated by the Climate Panel is by its nature often complex and nuanced.

Can the IPCC respond to these demands without compromising its core mandate of providing scientifically robust and rigorous assessments? This chapter will argue that while there are practical and institutional limits to Climate Panel communications, the Climate Panel can do and is doing more to communicate its work and findings.

Because of its salience in discussions about climate change, the IPCC and its communications attract considerable scrutiny. IPCC communications policy played a central part in the criticism that the IPCC encountered in 2009–10. And discussions around the IPCC and broader climate policy since then, in the run-up to the Paris Agreement and beyond, have to a large extent been dominated by questions about its ability to communicate its findings to non-specialist audiences, about accessibility and user-friendliness. In examining the background to IPCC approaches to communications, and how they are evolving, this chapter aims to further understanding of the communications work of the IPCC, while locating it in the policy context and the broader activities of climate communications. In so doing it may encourage further thinking on how IPCC communications can be strengthened.

This chapter is expressly practice-oriented. It draws on the author's experience of work at the Climate Panel in developing communications for the launch of the Fifth Assessment Report and the start of preparations for the Sixth Assessment cycle. While referring to the theoretical literature (by both IPCC practitioners and the research community) it does not seek to advance a theoretical understanding of IPCC communications; this may be achieved more effectively by others. Similarly, the insights come from the author's own particular perspective in the IPCC ecosystem, and any resulting imbalance is the author's responsibility.

[1]The names are *Global Warming of 1.5°C: an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty; Special Report on the Ocean and Cryosphere in a Changing Climate; and Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*.

2 History

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP, now UN Environment), in a decision subsequently endorsed by the U.N. General Assembly. Its role is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation (IPCC 1998). It was a unique organization (since then the model has been used for others), standing at the interface of science and policy.

As the name implies, it is an organization of governments, who come together to mobilize the scientific community to provide them with actionable scientific assessments that can inform policy at the local, national and international level. The Climate Panel is an assessment body; it does not conduct original research, collect data or construct models, but assesses published literature to inform policymakers of the state of relevant knowledge. In selecting authors it seeks experts known through their publications and works, while ensuring that the author team reflects the range of scientific, technical and socio-economic views and expertise, geographical and gender balance, and a mixture of experts with and without previous experience in the IPCC (1999). It provides objective information and does not make policy recommendations or set targets, though it may lay out options for action.

IPCC reports are prepared in a process of repeated drafting and review. The final draft of the SPM—the summary that attracts most attention from policymakers and the media—is examined line by line in a plenary session of the Panel, where government representatives review it for clarity and consistency with the underlying report, in consultation with a selection of the authors who wrote it. Changes sought by governments must be agreed among them by consensus and confirmed by the scientists, both for general accuracy and for consistency with the underlying report. New material not in the underlying chapters cannot be introduced into the SPM, and the scientists have the last word on changes and additions (although if there is serious disagreement, that text or graphic may be removed from the SPM).

While the work of the IPCC was well known from the outset in the scientific community and the broader policy and civil society communities, including parts of business, that follow climate change, it is fair to say that the organization did not impinge on the public consciousness in its early years. This changed dramatically with the delivery of the Fourth Assessment Report (AR4) in 2007 (IPCC 2007), which attracted widespread attention around the world for its findings which included:

- Warming of the climate system is unequivocal
- Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations

- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century
- Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change
- There is *high confidence* that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

As a result of this work the IPCC was awarded the Nobel Peace Prize in 2007 (shared with former United States Vice-President Al Gore), "*for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change*"—the citation explicitly noting its work in communicating climate change (Norwegian Nobel Committee 2007).

It is worth recalling that at this stage the IPCC did not even produce its own press releases, but relied on the sponsoring organizations, WMO and UNEP, to do so on its behalf. One reason for this was a simple lack of capacity in the IPCC Secretariat. Another reason was the concern that to highlight one part of the findings rather than another in press materials could undermine the balance of the approved SPM and thus provide a picture of the report that was not objective.

The IPCC now enjoyed a high profile, with its reports being described as the "bible" or "gold standard" of climate change. However, this made the IPCC an object of interest for those concerned at the possible economic and regulatory cost of the policy response to climate change. (For a discussion of how this played out in the political context of the United States in the previous years see Oreskes and Conway (2010). The result was a series of attacks in 2009 and 2010 on the credibility of scientists associated with the IPCC, and on the organization itself. The IPCC was ill equipped to handle these attacks, and its response to allegations of errors in AR4 was inadequate. For one thing, like many larger international organizations with dedicated communications teams, it had a poor understanding of how the media operate and the requirements of journalists in the news cycle. For one description of this period, see Van Ypersele and Gaino (2016).

With criticism of the IPCC threatening to undermine the organization, the Secretary-General of the United Nations and Chair of the IPCC invited the InterAcademy Council (IAC), an international body grouping academies of science, to examine the operations of the IPCC and come up with recommendations (InterAcademy Council 2010). Among the recommendations of the IAC, released in August 2010 was one for the Climate Panel to recruit a senior communications manager and develop a communications strategy. The strategy was completed in 2012,[2] as was a subsequent detailed implementation plan (IPCC 2012).

[2]At the time of writing it is being revised for consideration by the Panel in October 2016.

3 Challenges for AR5

By this stage work on AR5 was already underway, and two special reports, SRREN (Special Report on Renewable Energy Resources and Climate Change Mitigation) (IPCC 2011a) and SREX (Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation) (IPCC 2011b), that fed into AR5, had been completed.

3.1 Scientific Rigour Versus Clear Messaging

In preparing AR5, the authors and scientific leadership of the Climate Panel faced some important challenges as far as communications are concerned. One, common to all academic publications intended for a broad audience, is the tension between accessibility and scientific rigour. Indeed, it could be argued that commercial and public organizations are subject to a similar problem, with in-house lawyers trying to restrain the communications team. For the IPCC, this traditional tension had been exacerbated by the crisis of 2009–10. One of the criticisms directed at climate scientists and the Climate Panel in this period was that they tended to be alarmist to attract attention. As a result the scientific leadership of the Climate Panel was particularly concerned to avoid anything that could be remotely construed as sensational. At the same time users such as governments and civil society organizations were concerned that the important messages of the Climate Panel, from impacts to mitigation measures, could be obscured by a conservative approach to language.

In fact, this issue can always be resolved given effort and good will on both sides, and an appreciation that calls for more powerful messaging can shade into calls for advocacy. The press releases of the AR5 working group reports and Synthesis Report do succeed in conveying the key messages. The content was under the control of the working group co-chairs (for the Synthesis Report, the IPCC Chair), who sought technical advice from the communications team to ensure the press release worked for the media.

3.2 The Approved Text

But the IPCC has another particular challenge in this area, arguably unique to the organization. Because the text of the SPM is finalized during a plenary session of the working group or Panel in a dialogue between government representatives (who commissioned the report and will work with it) and the scientists (who wrote it), the text takes on a quasi-legal status. The discussion at the approval plenary focuses on clarity and consistency with the underlying report. Co-chairs and authors will generally agree that what emerges is a better, and more policy-relevant, text than

went in as a final draft. But sometimes changes are made with a view to the use the text may be put to in negotiations, and the result then can be a finely balanced diplomatic compromise. This process in itself—fundamental to the preparation of the report—has been attacked as a politicization of the IPCC process, ignoring the fact that the reports are prepared for governments to use in their climate-related work, and that any changes must be signed off by the scientists present. (For a discussion of this process see Mach et al. 2016.) But this special status of an IPCC SPM text means that it is very difficult to deviate from the approved language in subsequent communications materials. To do so risks not only losing scientific rigour, but also unravelling a carefully constructed balance, where a particular phrasing may be important to a government.

This is one reason why, historically, the IPCC did not produce press releases on its reports before AR5. For AR5 the co-chairs and Chair had the authority to find language that was scientifically robust and which could be modified in the light of the discussions in the approval plenary so that it reflected the SPM text but was still more accessible for media purposes.

Respect for the approved text of an SPM will remain a feature of IPCC communications. It imposes a challenge on the authors of the SPM and those chairing an approval plenary to find language that is clear and accessible—and thus can be used in communications materials—while also meeting acceptance in the session.

3.3 Credibility

For the release of AR5, the IPCC faced a new challenge. Having been seen as the gold standard for climate-related science after AR4, its credibility was severely tested in the 2009–10 crisis. The slow and inadequate response to allegations of errors in AR4 cost the IPCC the sympathy of the media.

The IPCC's procedures in preparing reports added to this picture. Traditionally the IPCC would only discuss the final, approved text of a report; the scientific leadership felt that it was inappropriate to discuss earlier drafts still subject to change, and which are circulated to reviewers on condition they remain confidential. Indeed, a comment by an IPCC official on the wording in a draft could be seen to prejudge the outcome of an approval session. But a routine "no comment" to reporters' questions when the drafts inevitably leaked created the impression of an unresponsive organization working with inaccessible materials. Getting hold of an IPCC draft became a sport for some in the media, who could then produce stories about the IPCC being "embarrassed" yet again by a leak.

3.3.1 Uncertainty

The treatment of uncertainty is a major challenge in communicating science or medical questions, and the IPCC is no exception. Indeed, an assessment of the

certainty of findings is fundamental to the IPCC work. For scientists this is normal, but uncertainty levels can be confusing for non-specialists. Simply put, lay readers see uncertainty as highlighting what is not known, whereas for scientists it expresses conservatively what is known; this makes it extremely challenging to communicate uncertainty clearly (Corner et al. 2015).

The treatment of uncertainty is a classic example of how scientists and non-specialists may interpret a text differently. For AR5 the IPCC developed new and standardized guidelines on how to use uncertainty language (Mastrandrea et al. 2010).

3.3.2 Use of Images

It is a commonplace that pictures can be more effective in communicating than words. The Climate Panel uses graphics, but in its reports, apart from the covers, has avoided photos, which by definition are selective and therefore unbalanced. This contrasts, say, with the US National Climate Assessment, which uses photos of individuals dealing with climate change to deliver an emotionally telling and upbeat message (National Climate Assessment 2014).

4 AR5 Actions

One of the first actions, even as the new communications strategy was being bedded down, was to rebuild relations with the media, which had been undermined by the handling of the crisis in 2009–10. At one level this simply involved showing that the Climate Panel was responsive. Many questions from the media for the IPCC seek comments on some new development. By definition, the IPCC as IPCC is unable to comment on something that has not gone through the formal approval process. All it can do institutionally is refer to the relevant section of the previously approved report. As well as doing that—providing the official IPCC response—the IPCC now also puts reporters in touch with the authors of the relevant section, who they could interview as experts in their own right, while mentioning the IPCC connection, rather than as IPCC spokespeople. Thus the IPCC positioned itself as a resource for reporters.

At a more technical level, the new communications team was able to draw on an understanding of how the media operates by introducing embargoed releases of reports. This makes materials available to accredited or registered reporters in advance of the release, allowing them more time study the documents and thus produce more thoughtful articles. It is a system widely used with reporters covering science, health or finance, where reporters may be confronted with materials of some length and complexity, in which there is strong public interest. Without an embargo, reporters are under pressure to produce articles fast, which may be superficial or open to error. This process was trialled with the publication of the full SREX report in 2012, and then rolled out for the working group contributions of

AR5. Several reporters even took the trouble to thank the IPCC for this during the press conference. There was some nervousness internally in the IPCC and among media that individual reporters would break the embargo by releasing stories as soon as they got access, prompting a free-for-all among their peers and undermining the subsequent press conference. In the event, at least for SREX and AR5, all media respected the embargo. This approach greatly contributed to the restoration of credibility with the media.

Building on the embargo for reports and press releases, the IPCC also introduced embargoed briefings between finalization of the report and the release of the report at the press conference. This provided a wide range of key media with quotes from the scientific leadership. This was all part of a professionalization of the media operation, which benefited from the secondment of communications experts from foundations at the time of the report releases. These saw the introduction of press releases, already mentioned, and a much more structured and pro-active approach to interviews with authors following the release of a report, including the provision of facilities for broadcasters.

The problem of leaked drafts has already been mentioned. Most reporters getting access to these texts would seek comment from the IPCC. The scientific leadership gradually came to realize that the routine "no comment" was unhelpful. Reporters would write stories anyway, which could be misleading, and the IPCC was passing up an opportunity to steer them in the right direction. Some officials have experimented with off-the-record guidance to reporters, and this will need to be developed in a way that does not prejudge the final outcome of the reports.

For AR5 the IPCC also produced a set of videos, one for each working group and an overarching summary, that delivered the key messages of the assessment, while showing how the IPCC functions and also presenting individual scientists at work. The videos deliver information concisely and with compelling imagery. The use of a professional filmmaker ensured compelling production values. At the same time content was firmly under the control of the working group co-chairs (or the Chair for the overarching summary). They and the authors they chose to be included had the authority to talk about the findings in their own words, because these were rooted in the approved SPM language. Scripts and scenarios went through repeated iterations between the co-chairs and the film producer to ensure effective communication coupled with scientific rigour and accuracy.

One of the most important communications tools for AR5 emerged, not from the communications team, but the scientific leadership of Working Group I. The co-chairs developed headline statements to summarize the SPM. Importantly these statements, each heading a section in the SPM text, were developed organically as the SPM was prepared, and not bolted on afterwards. This meant that in the WGI SPM approval session, after nearly four days of discussion on the text, the headline statements were approved relatively quickly with little discussion. The 19 headline statements, on two sides of paper, form a coherent narrative (IPCC 2013). They were widely used for communicating the WGI findings by policymakers and other stakeholders; one author even turned them into a widely circulated set of haiku.

Governments were so impressed with them that they asked the other two working groups to develop sets. But work on their SPMs was already advanced, and it was not possible to develop headline statements deriving from the text that would meet approval. However, headline statements were produced for the Synthesis Report (IPCC 2014b). For further discussion of headline statements see Stocker et al. (2016).

Another extremely important tool emerged from the UNFCCC process. This was the Structured Expert Dialogue in which negotiators were briefed by IPCC authors and other scientists. The dialogues, held during UNFCCC negotiating sessions, allowed negotiators to question IPCC authors in detail about the findings and thus gain a thorough understanding, contributing importantly to the final Paris Agreement (UNFCCC 2016).

The IPCC had always presented its findings to various audiences in different countries. In 2014, as AR5 was finalized and it became clear that there would be a push to reach a climate agreement at the UNFCCC the following year, it decided to embark on a much more ambitious programme of outreach to keep the findings of the IPCC uppermost in the minds of policymakers and other stakeholders. These outreach activities (detailed here: http://www.ipcc.ch/apps/outreach/index.php) involved the IPCC presenting the findings of AR5 and the work of the IPCC around the world to audiences of policymakers at all levels, practitioners, scientists and the media. They succeeded in informing the discussion in the countries about climate change, often supported by high-level political participation from the government, and encouraging media coverage. The larger events typically involved seminars with local scientists, policymakers and practitioners to discuss local approaches to climate change and how they could be informed by the IPCC's findings, and workshops with young scientists to encourage them to work with the Climate Panel.

5 What Next?

The 41st Session of the Panel in February 2015, with AR5 completed four months earlier, was devoted to consideration of the IPCC's future work. At the suggestion of Norway, it was decided to hold an expert meeting on IPCC communications to review the experience of communicating AR5 and pass on lessons learned to the new scientific leadership to be elected later that year. The expert meeting took place in Oslo a year later, and provided an opportunity to reaffirm some of the communications successes of the previous 4 years, consider what could have been done better, and address some of the criticisms about access and clarity that the Climate Panel had encountered.

The expert meeting resulted in a large number of recommendations, but also an acceptance that there were limits to what the IPCC could accomplish in terms of communication, with its limited capacity including small permanent staff. To reach a wide range of different audiences in different countries, the needs other bodies to act as multipliers by producing targeted materials and organizing events directed at

particular audiences. One challenge for the IPCC therefore is to ensure that its materials and activities form a usable resource that others can work with. Another is to find ways of engaging with such third parties in a way that does not compromise the IPCC's mandate, objectivity or independence.

Already in the first version of the communications strategy, the Climate Panel recognized the value of "derivative products" produced by third parties without IPCC endorsement. The IPCC has a clear interest in ensuring that such products, while not constrained in the same way as official IPCC materials, give an accurate picture of what the IPCC is saying. The IPCC needs to develop a process and criteria under which it will work with some third parties to produce these materials, without being overwhelmed by proposals or selecting projects arbitrarily. Managed effectively, this can bring the findings of the IPCC to diverse audiences all over the world.

Not surprisingly one of the main recommendations was to update the communications strategy in the light of the experience of AR5 and the discussions at the expert meeting. The Panel agreed to this and an updated strategy was due to be submitted to the Panel in October 2016. Several members of the Panel also expressed the view that not all the recommendations of the expert meeting were practical or within the IPCC's mandate, a particular constraint being the need to avoid incurring any extra financial burden.

The expert meeting also recognized that better and more effective communication was not simply a question of livelier adjectives in the text and more striking graphics. It is also important to look at the sociological and psychological findings of the science of science communications, to consider how scientific information is perceived and processed, and how scientists can communicate information most effectively. It is clear that the special report on the impacts of 1.5 °C and related emissions pathways to be delivered in 2018 will attract a lot of interest and will pose particular challenges in communicating with non-specialists. The IPCC intends to hold an expert meeting in 2018 to bring together some of the newly selected authors for AR6 with experts in the science of science communications.

This reflects another important insight from the expert meeting: that communications should be considered from the outset of work on an IPCC report. Just as the headline statements were developed together with the SPM in AR5, the authors, at least for the SPM, need to think from the start how what they produce will be communicated. This in turn means bringing if possible communications expertise into the author teams and technical support units, for instance science writers or graphics designers.

Every IPCC report starts with a scoping meeting, in which experts nominated by governments, observer organizations and the IPCC Bureau draw up the outline of the report—its contents and structure—which are then considered and approved by the Panel. These experts are drawn mainly from the scientific community and government, but also include practitioners and representatives from civil society. There is a growing understanding that it would be beneficial to engage more closely with a wider range of stakeholders when reports are being prepared in this way, without losing focus or setting up an incoherent process. For the special reports in

the current cycle and the main AR6 assessment itself, the IPCC is experimenting with different options, for instance circulating questionnaires on scoping or taking part in international conferences organized by others.

Better and greater use of visual materials also offers the IPCC opportunities. It must be recognized that simple, vivid forms of communication will not always be practical for the IPCC. For instance IPCC texts are carefully developed by scientific authors to show uncertainties, while a range of scenarios is shown to avoid being prescriptive. This material goes through an approval process requiring unanimous agreement from government representatives, deferring to the authors for any changes they wish to propose. An attempt to simplify language or make a graphic more immediate could damage this balance, inviting criticism from both scientists and governments. Moreover some research suggests that such simplifications, frequently urged on the IPCC, may even be counter-productive. A recent study on how images are perceived, comparing IPCC visuals with infographics, found that visuals in an IPCC SPM inspired confidence in the reader because "they look scientific", while more accessible infographics were found to look less serious and left readers feeling less confident (McMahon et al. 2016). At the same time, some graphics produced by climate scientists have been recognized as highly effective, such as this example of an animated spiral showing temperature rise (Hawkins 2016). If the IPCC cannot produce such materials itself, it can work with third parties to ensure they accurately communicate IPCC messages.

Lastly, the preparations for AR6 are unfolding in a rapidly changing media, especially social media, environment. Already many young people at least in rich countries consume information by video on social media platforms on handheld devices. Traditional media players are changing and disappearing; new ones are appearing. It is clear that a communications strategy updated in 2016 may already be out of date by the time AR6 appears. The IPCC will need to keep abreast of these changes.

The innovations in communications in AR5 showed the IPCC that communications tools, far from weakening or distorting its message, could if used correctly deliver it effectively. The scientific leadership elected in 2015 is keen to build on this experience while upholding standards of scientific rigour. The preparation of AR6 offers the IPCC new opportunities for communication, and stands fair to benefit from them.

And yet, there are limits to what the IPCC can achieve in communications. As indicated above, one of the key insights of the Oslo meeting was that, as far as communications are concerned, the Climate Panel cannot do everything. It simply does not have the capacity to reach all audiences effectively; third parties have an important role to play, with or without active IPCC engagement. The scientific leadership recognizes the importance of communications and in the AR6 cycle wants to give them greater priority. But in the end, however much communications are embedded in the IPCC process, the scientific leadership does not want to see them become the tail that wags the dog. Member governments too welcome efforts to promote clarity, and make IPCC products more user-friendly. But many of them are content to see the IPCC provide the basics, which they can draw on for their own communications work.

6 Conclusions

This chapter has tried to show how IPCC communications have developed in recent years, and how they could continue to evolve in the future. IPCC communications have become more effective: the Paris Agreement and demand in developing countries and elsewhere for more IPCC outreach is evidence of that. These changes are unfolding within practical and policy constraints that make radical changes unlikely. Nevertheless, the insights of other practitioners in civil society and scientific institutions involved in communicating climate change, as well as the research community that is increasingly engaging directly with the Climate Panel, can contribute to further advances in IPCC communications.

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Performative Methods for Climate Change Communication in Academic Settings: Case Study of the Freiburg Scientific Theatre

Sadhbh Juárez-Bourke

1 Introduction

Climate change is not easy to communicate. First, its inherent complexity makes it hard to explain (Hulme 2009; Spence and Pidgeon 2010). Secondly, its abstract and uncertain quality makes it hard to believe (Akerlof et al. 2012; Budescu et al. 2012; Moser 2010; Moser and Dilling 2011), and finally, the negative future scenarios it predicts make it a hard belief to live with (CRED 2009; Moser 2006). Since the United Nations Convention on Climate Change in Rio 1992, there has been a conscious effort to make sound scientific knowledge accessible to the public (Eden 1996). However, although knowledge is necessary (O'Connor et al. 2002) by now it has been well established that knowledge in itself is not enough to foster behavioural change (Kahan et al. 2012; Gardner and Stern 2002; Moser and Dilling 2011; Nerlich et al. 2010). In fact, translating knowledge into effective action has been identified as one of the most pressing challenges of climate change communication, along with superficial understanding of the topic by lay people, communicating in highly politicised environments, and the feelings of hopelessness that climate change often inspires (Moser 2016). There is now an emerging understanding that climate change communication must include behavioural, affective and cognitive dimensions (Lorenzoni et al. 2007) and be embedded within deliberative frameworks that move away from traditional one-way communication approaches (Dietz 2013). In this context, there has been an increasing interest within climate change communication literature in studying the role of culture, values and beliefs (e.g. Kahan et al. 2012; Corner et al. 2015 for a review), as well

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as the role of emotions (e.g. Roeser 2012), and more broadly that of the arts and humanities, in order to articulate the use of communication formats that mobilise these elements (see Moser 2016 for an extensive review).

1.1 Producing Actionable Knowledge

Designing communication formats that include normative, emotional, deliberative and contextual dimensions while also transmitting the complexity of climate change is a challenge. It requires us to re-think and re-frame not only the way we communicate, but the way we produce knowledge, and the type of knowledge we produce in academia. Rommetveit et al. (2010) elegantly outline how the challenge to produce actionable knowledge can be at least partially related to the foundations of scientific knowledge: the original aim of reaching truth through objectivity involves removing the context in which knowledge is created in order to make it replicable. However, by removing context and normativity from knowledge—its subjective attributes—we then encounter the problem of how to make it relevant for society and conducive to behavioural change towards common goals. While this problem has been widely addressed within the social sciences from a theoretical perspective, giving way to critical, post-normal and constructivist re-framings of knowledge production (e.g. Bochner 1994), it remains problematic in practice, as we find when addressing policy design and communication strategies for climate change (Adger et al. 2013).

The question of truth and validity of scientific knowledge is especially salient when referring to climate change (Hulme 2009). While Kahan et al. (2012) found empirical evidence that discrepancies about climate change have more to do with peoples' cultural values than with their levels of literacy and numeracy, Esbjörn-Hargens (2010) portrays climate change as having multiple rather than one ontology as a result of people's different world-views. This argument supports the limitations of approaching climate change communication from a one-way knowledge transfer perspective. Communication formats need to take into account this diversity of world-views and values, not only to tailor communication and policy to people's values in order to increase efficiency (Persson et al. 2015), nor to use knowledge of people's values to design policies that better control people's behaviour, as some studies suggest (e.g. Schoenefeld and McCauley 2016), but to create communication formats in which, in addition to transferring scientific knowledge, differing values are articulated and can be negotiated in a process of social learning (Dietz 2013).

1.2 Aims of the Article

Within the context of climate change communication, and in response to the challenges outlined above, in this article I explore the potential of the arts to give us access to the aspects of communication that are traditionally not part of science

practice—such as connecting to emotions, providing context, conveying complexity and providing spaces for deliberation in which different normative assumptions can be negotiated—what I call "incorporating subjectivity" to science communication. For this I draw on my personal experience as part of the Freiburg Scientific Theatre project.

Over the course of five years, the Freiburg Scientific Theatre developed a theatre method for communicating complex sustainability issues at academic conferences. Formed by a group of sustainability researchers and practitioners from diverse cultural and professional backgrounds and with no former experience in theatre, this process is an explicit example of how theatre methods can support knowledge integration, co-production and transfer within academia. I first provide an overview of arts-based research, focusing on findings from the field of health and a recent study on the use of performative methods in the environmental field. I then describe the Freiburg Scientific Theatre method developed by the group to co-create theatre plays. From the model described, I identify six performative functions, which I support with narrative extracts and testimonials from the audience. Finally, I discuss these findings in the light of their implications for climate change communication. I then summarise the conclusions of the article, outline some of its limitations and describe potentials for future research in this direction.

My overall goal is to provide a better understanding of how theatre can help communicate complex issues such as climate change, focusing on the mechanisms by which subjective attributes are incorporated into both the creation of a message and its communication to an audience. This paper also wants to be an invitation to further explore the potential of transcending disciplinary boundaries and drawing from ethnographic research methodologies to gain insights for designing effective deliberative communication formats.

1.3 Theatre in Academia: Arts-Based Research and Performative Methods

While science is our attempt to objectively understand the world through empirical and replicable evidence, art—as Goethe put it—is the "mediator of the inexpressible". The arts give us access to different ways of knowing and enhanced perspectives (Barone and Eisner 2012) and can create types of meaning that are not accessible to us through scientific endeavour (Scheffer et al. 2015). Consequently, arts-based research has been receiving increasing attention as a way of having access to normative dimensions of sustainability and governance and providing alternative ways of meaning making (Leavy 2009). Within the field of health, arts-based research—and specifically theatre—has received considerable attention as a tool for knowledge transfer for health experts, and for health experts themselves to improve their practice when dealing directly with patients (e.g. Mitchell et al. 2006). Arts-based research in this field has been found to provide knowledge integration and contextualisation (Lévesque et al. 2015), to communicate

complexity (Mitchell et al. 2011) and to elucidate self-reflectivity, empathy and compassion (Kontos et al. 2012; Dupuis et al. 2015). Empirical evidence about its ability to foster long-term behavioural change has also been documented in this context (Dupuis et al. 2016).

While applied theatre (sensu Nicholson 2005) has been adopted in academia mainly in the fields of health and education (Heras and Tàbara 2014; Leavy 2009) there has been little systematic assessment or application within the environmental and sustainability fields (Heras and Tàbara 2014). Heras and Tàbara (2014) have recently begun to address this gap, defining the concept of performative methods within sustainability science as a form of research "devised to support individual, community and institutional reflexivity and transformation" (ibid., p. 10). Based on a review of applied theatre in sustainability contexts, they identify five potential functions of performative methods, which can be summarised as: integrating knowledge and values, communicating complexity, fostering reflexivity and deliberation, building socio-ecological identities and fostering emotional commitment leading to action.

Many of the forms of participative theatre we encounter today—as well as that of the case study presented here—are inspired by the body of work of dramatist Augusto Boal. Influenced by Paulo Freire's critical pedagogy, in which education is seen as a form of resistance to political oppression (Freire 1970), Boal (1992, 1995) developed an extensive methodology—known as the Theatre of the Oppressed—for using theatre as a tool for enabling processes of social and individual transformation. In this context, the role of theatre transcends the notion of a one-way communication method, and can be embedded within a broader concept of "social learning" (sensu Reed et al. 2010).

2 Using Theatre to Communicate Sustainability Science at the Freiburg Scientific Theatre

2.1 Research Approach

In order to extract relevant information from the Freiburg Scientific Theatre initiative, I use an autoethnographical methodology. Rooted in postmodern philosophy, autoethnography gains access to knowledge about society and culture through the narratives of the researchers' lived experience (Jorgenson 2002; Ellis et al. 2010; Holman Jones 2005). Autoethnography questions established forms of creating meaning within science, which is fitting for the topics raised in this paper. Richardson (1994 as cited in Wall 2006) describes writing not only as a way of "telling" but as a way of "knowing". Richardson (2000) also defines the act of writing as a "*method* of discovery" (p. 967, italics original). Charmaz (1983 as cited in Ellis et al. 2010) notes how meaning emerges from the experience itself, which is regarded more as a source of questions than a measure of truth. Autoethnography does however raise questions about its ability to produce reliable, generalizable and

valid data, as it does not follow our conventional notions of objectivity, reason and truth as ways to produce knowledge (Ellis et al. 2010). Nevertheless, bearing in mind the methodological challenges we currently face to evaluate the effects of aesthetics, imagination and effective communication (and without aiming to overcome these challenges here), in this context, my reference point for validity is "what is useful" rather than what is "rigorous systematic science", inspired by Bochner (1994). Without claiming that these are necessary excluding characteristics, rather than claiming "truth" in this paper I aim for "truthfulness" by choosing narrative as a methodology to access experience-based knowledge (Leavy 2009). In narrative approaches, analysis occurs simultaneously with the writing process, rather than after data collection (Gehart et al. 2007, p. 381). Thus in describing my experience I also identify potential qualities or "functions" of performative methods drawing from Heras and Tàbara (2014) but extending their concept—which is embedded in community-oriented processes—to the specific functions that emerge in the academic context in which the Freiburg Scientific Theatre experience transpires.

2.2 *Introduction of the Case Study*

The Freiburg Scientific Theatre (hereafter FST), is formed by an intercultural group of sustainability science researchers from diverse academic and professional backgrounds, based in Freiburg (Germany), who use theatre as a tool to communicate sustainability issues. The project emerged in 2011 as part of a student-organised event from the M.Sc. in Environmental Governance. As part of the programme syllabus, each year students organise a conference on a sustainability topic of their choice. Motivated by the wish to bridge the theoretical content of the studies with the reality of daily life, the idea of creating a theatre play to be performed during the conference emerged. Following the success of this first performance, the group of students began to perform for academic audiences at sustainability conferences around the country, hoping that "by appealing to the emotions, not just the mind, we can engage and provoke audience members at a deeper level than is possible with traditional science communication methods" (Freiburg Scientific Theatre e.V. 2016).

To date three main productions have been developed: *Setting the Stage Towards Sustainable Consumption*, which is focused on different aspects of food production and distribution; B*achata in Fukushima*, which explores governance issues around different forms of energy production, and *Paradise Vetoed—Stories of Climate Change*, which revolves around an imaginary COP21 on an island in the pacific. Most performances draw from a pool of previous sketches from these three productions, which are then combined with new material developed specifically to fit the topic of each conference. To date the FST has delivered over 30 performances, mostly at academic conferences and occasionally at public and private events related to sustainability.

2.3 The Freiburg Scientific Theatre Model

The FST initially hired a theatre director to help the first members of the group create a theatre play for the student-organised event described above. After that, the FST has continued to function as a self-governed group of 8–12 academic-actors, collaborating occasionally with theatre teachers to help improve acting skills, polish material and create new plays. This method is significantly different to those documented by other arts-based research studies in the literature, where the creation of the theatre play is usually already included in the research design. In this case, the way of working has been left open and flexible, allowing for the project to evolve along with changing members and circumstances. Nonetheless, a tacit working method has gradually emerged. For the sake of clarity, this process is described below as a series of consecutive steps, although in praxis it is an iterative process.

Step 1. **Introduction to theatre** The first weeks of the project consist in being trained into basic theatre skills through games and exercises. As new members enter the group, they are trained by the more experienced members.

Step 2. **Brainstorming and research** The theme for the play is usually determined to match the topic of the conference at which it is to be performed. This research phase involves drawing mainly form the combined knowledge of the group of academics and practitioners that form the FST, which is complemented with additional individual research to gain a better understanding of the topic.

Step 3. **Creating sketches through improvisation** The creation of content for the play starts with doing improvisations based on the selected theme. Sometimes two groups of four or five people create improvisations separately on the same topic in order to get a broader range of ideas and perspectives. Selected improvisations are then used as a basis to create sketches.

Step 4. **Creating a storyline** Once a relevant number of sketches has been developed, a "meta-story" is jointly created to string together the sketches and tailor the performance to the upcoming event.

Tangible outcomes: a performance and a discussion with the audience The end result is a play of 40–50 min, usually performed at a conference venue. The play is often performed as entertainment at the opening or closing of the event of the conference, or in some cases inserted as 15 min interludes between lectures. The acting style is tragicomic, with cultural, gender, and profession stereotypes used to bring humour into many scenes as a counterpoint to the tragic realities that are being portrayed. The objective of the performance is that the audience have an entertaining experience and leave feeling inspired, rather than being overcome with feelings of guilt and "doom and gloom". The play is usually followed by a discussion with the audience.

2.4 Performative Functions of the Freiburg Scientific Theatre

I identified six performative functions based on my experience at the FST. My aim in identifying these functions is to provide a description of how the "subjective attributes" of sustainability are incorporated though the theatre practice. The first three functions refer mainly to the creative process: having access to different ways of knowing and doing through the theatre practice, integrating different types of knowledge and cultural perspectives, social learning and transformational learning at a personal level. The other three refer to the actual performance: being able to articulate complexity, humanising scientific discourse, and creating a platform for deliberation with the audience. In the following section, I discuss each of these functions, using a first-person-plural voice as well as series of singular fist-person narratives.

1. **Accessing different ways of knowing and doing** The first thing we learned at rehearsals was to transition our consciousness from our head to our bodies "*Stop discussing, just do it!*". Being used to our academic culture of intellectual debate, our theatre practices would easily break into long discussions about the topic we wanted to represent. Thanks to the persistence of our director, we slowly learned a new culture, that of letting our bodies speak on stage (see narrative 1). Boal (1995) considered theatre a distinct form of knowledge. And indeed, theatre introduced us to a different way of knowing. By letting our bodies speak for ourselves, we experienced a different ways of being—and therefore knowing—that we do not have access to through intellectual endeavours. According to Gray (2009, p. 6) "the *presence of the body itself* carries great weight in communicating or challenging an idea" (italics in original). By bringing the whole body back into the process of knowledge transfer, we can add layers of nuance, meaning, and emotion that cannot be captured otherwise.

Narrative 1—Working with poems *In the early days of our training, the director introduced us to two parallel exercises: one was to work in pairs, standing in front of each other, hold hands, and start experimenting with different positions without letting go of our hands. Eventually, we created a sort of choreography, memorising each of the transitions to a new position. Then we let go of each other, and memorised the positions individually. This process was developed over a few rehearsals. Parallel to this, we had been asked to choose a poem of our liking that we found relevant to what we wanted to communicate in our play, memorize it, and recite it to the group. Then we were asked to combine our poem with the body movements we had learned, finding a way for each to enhance the other. Once we had found a way of coordinating them, the body movements were minimised again, to be less theatrical and more nuanced. Magically, our poems and our movement*

were elevated to another level. We were no longer speaking from our head, but with our whole being. As we performed our piece for each other, I got chills all over my body. We have often used this powerful technique as a creative resource in our plays, as it helps to connect content with emotions, create a sense of deeper knowingness and a particular atmosphere.

Through the theatre experience we also learnt about alternative ways of dealing with conflicting perspectives: rather than taking an argumentative approach to overcome our differences (as we were used to doing in class and daily life) the aesthetic space allows for opposed needs, desires and perspectives to co-exist. In fact, without conflict, there is no theatre (Boal 1995). Every time we found ourselves not knowing what the outcome of a story should be, we were reminded to let our questions be answered by the stage. The resolution of the problem did not come from a rational space; it revealed itself through the improvisation. Thus, we were introduced not only to different ways of knowing, but were offered the possibility of a different way of behaving when confronted with multiple perspectives.

2. Integrating different types of knowledge

The aforementioned qualities of the aesthetic space, which allow for the body to speak and for different—often-conflicting—perspectives to coexist, provided us with a space in which it was possible for us to integrate our scientific knowledge with emotions and context. This happened by bringing in narratives to flesh out the facts that we wanted to draw attention to. For example, when addressing the topic of food consumption, we told the story of two tomato farmers (see narrative 2). In fact, any time we set out to explain the mechanisms of a certain problematic in an improvisation, what always happened was that our scientific knowledge provided the canvas, but the story was brought alive by the narrative of our personal experiences relative to the topic. Even if the story was fictitious, it drew from our local identity, professional knowledge, or personal experience, stories that we identified with or related to at an emotional level. The use of music, dance and poetry from our diverse cultural backgrounds also allowed us to create atmospheres which contained references of our cultural heritage, and about the feelings that the situations we were portraying evoked in us. So not only did we have access to different types of knowledge through our discovery of theatre, we also found in theatre a medium in which to integrate these different ways of knowing.

Narrative 2: ***The tomato farm*** *We're working on the topic of food consumption, trying out improvisations around this topic. One of the things we want to make visible is the value chain of food production. I'm thinking about the south of Spain (where I'm from), which has become a major producer of tomatoes in the world. But I start my improvisation with something that is more real to me—although I have never actually experienced this—two farmers, mother and daughter. We talk in Spanish with a southern accent. While we work the land, we sing a popular communist song from the 40s, which I knew from one of the teenage rock bands I used to listen to. From this improvisation, our story emerges. The farmers work the land, selling tomatoes to their neighbour, engaging in friendly banter. Gradually,*

the distance between farmers and neighbour increases, as middlemen appear between us—transport, packaging, supermarket etc.*—the price we get from our tomatoes decreases, as our work increases. We start panting while we sing, until our voices are hardly audible. As we struggle to get by, our mother–daughter relationship becomes strained. Finally, we collapse. Our neighbour is disgusted at the taste of the canned tomatoes he gets at the supermarket. The whole scene lasts no more than five minutes*.

3. **Personal transformation and social learning**

The aesthetic space has "properties which stimulate the process of learning by experience" Boal (1995, p. 28). Our intense, time-consuming, self-governed process of co-creating performances without a theatre director presented many opportunities for personal growth and reflection. On one hand, through the practice of theatre we developed presence, body-awareness and self-confidence, and learnt to be vulnerable in front of other individuals. At the same time, tensions around leadership and roles, level of engagement, and artistic differences, preferences for approaching decision-making and feedback, personalities and cultural differences (such as punctuality) were on-going challenges. By navigating and overcoming these tensions, we experienced connection, built trust, shared knowing and created a group identity. We also re-defined relationships, and increased our self-awareness, through our interactions with each other.

4. **Articulating complexity**

> … great job in challenging people, pushing them to go beyond the usual sustainability mantras, picking up on contradictions in our discussions – you could tell they have an in-depth understanding of the topic…. —Ania Rok, Governance & Social Innovation Officer, ICLEI European Secretariat

Theatre de-constructs the linear perception of a single truth by constructing narratives in which multiple perspectives are represented (Denzin 1997 cited in Rossiter et al. 2008). Building on our integration of different ways of knowing and different types of knowledge, our performances were able to articulate to the audience the many layers of complexity of the topics we were dealing with to the audience. By combining the diversity of cultural, ideological and disciplinary perspectives that we brought as a group, our performances offered the audience a global perspective of the topic, while keeping them in touch with local realities and personal stories that they could relate to. Heras and Tàbara (2014) note the crucial role that the aesthetic experience of theatre—for instance the use of metaphors and the possibility of the image to convey multiple meanings—plays in conveying complexity. We often noticed how the metaphors we had used in the play would be picked up by speakers and participants to bring their point across more clearly during conference presentations and discussions.

5. Humanising the discourse: humour, empathy and diversity

> …you confronted the audience with the serious problems and uncomfortable challenges we face when dealing with sustainability issues and at the same time made us laugh using a wonderful humour and thus leaving us hopeful and inspired to take action and make a change in the world. —Sophie Hirschelmann, Institute of Botany and Landscape Ecology, University Greifswald

One of the challenges when creating our plays is to find a balance between avoiding a heavily moralistic didactic message with a non-credible happy ending, and avoiding a bleak picture of reality that will create a sense of hopelessness in the audience. According to Jackson (2007 cited in Gray and Kontos 2015) it is by leaving "creative gaps" that allow for interpretation that the audience can engage emotionally and be self-reflexive about their assumptions about the world, rather than receiving a message which is too direct, where the message might be rejected altogether. We experienced in our own process, where the use of aesthetic elements, such as images, metaphors and poetic representations, as well as the use of narratives, allowed us to reach the audience at an emotional level and engage in animated discussions after the play. As for avoiding the catastrophic "doom and gloom" atmosphere typical of sustainability discussions, our approach was to make use of humour, in the form of parody and caricature. Our diversity played a big part in achieving both of these aspects, enabling us to portray authentic experiences through fictional yet truthful narratives, while also giving us licence to play on stereotypes (of our own cultures and backgrounds) to bring in humour. As with most of our process, this was not pre-meditated, but emerged organically from our practice. Reflecting on our experience, it is finding that delicate balance between empathy and humour—while avoiding sentimentalism and cynicism—that is key to conveying a message that is both motivating and authentic.

6. Creating a platform for deliberation

> The combination of science and art is a powerful way of making a point about a topic, while revealing its layers of facts and emotions, and showing the individual and social impacts … The Scientific Theatre succeeded in bringing these points into their play and in increasing the conference participants' awareness and motivation to explore—Manuel Böhm, Organising Committee—LERU Bright Conference 2013

Creating spaces for dialogue with the audience is crucial in order to negotiate meanings and incorporate perspectives (Leavy 2009) as well as avoiding "didactic" approaches (Goldstein et al. 2014). The space for deliberation after our performances was an important point in which the audience had the opportunity to accept or reject the perspectives that we had presented. By offering a space for participation, the audience had the chance to question the picture of reality that we had painted for them. What made this different from other academic debates is that having been exposed to a variety of perspectives and to feelings of empathy for the characters embodying them, spectators usually speak from what feels like a "softer" perspective than that which ensues usual academic presentations. Furthermore, because our performances include perspectives of many different stakeholders—

even giving voice to nature—it allows for discussions on differing world-views and values. This deliberative space was not confined to the discussions at the end of the performance. Instead, it had already started amongst ourselves while co-creating the plays. As described earlier, theatre gives us access to different ways of knowing and doing: the use of improvisation allows us to approach different perspectives with curiosity, rather than a preconceived agenda of what the outcome should be to represent our own values and beliefs. Because of the make-believe quality of the theatre setting, it provides a safe space for us to consider different beliefs and value systems, without it feeling like a threat to our own values and beliefs.

3 Implications for Climate Change Communication: From Knowledge Transfer to Knowledge for Transformation

Producing actionable knowledge is a major challenge for climate change communication (Moser 2016). A recent study on communicating climate change adaptation (Wirth et al. 2014) found that most communication formats need to go beyond content in order to better address emotions, norms, values and trust. Amongst the 16 success factors they identified, are the need for communication formats to connect to the audience's daily lives, provide context, convey authenticity and elucidate empathy while providing sound scientific knowledge. It is safe to say that the FST addresses these factors: we have seen how the aesthetic space created in theatre allows for the integration of stories with facts, and lends itself to emotional engagement and self-reflectivity. In fact, the FST addresses all of the 16 success factors identified by Wirth and colleagues, except for two: suggesting solutions and evaluating the effectiveness of communication. Let us discuss them in more depth.

As argued above, at the FST we found it more empowering to provide a space of deliberation rather than to suggest specific solutions to the audience in our plays, and this approach concurs with other findings based on performative methods. I suggest that this discrepancy between performative methods and climate change communication formats is because each have different underlying assumptions and goals. While the focus of climate change communication is to produce tangible products and outcomes and to achieve specific behavioural changes, theatre-based research puts more focus on the actual process of knowledge co-creation and the process of reflexivity and transformation (Leavy 2009). Without implying that no solutions should be provided in communication formats, we need to be weary of not going from a "knowledge deficit" model to a "behaviour deficit" model, in which we include people's values only as a way to better control their behaviour and adoption of policies, as discussions in the literature are tending to do (e.g. Nerlich et al. 2010; Schoenefeld and McCauley 2016). Performative methods offer a format, which allows us to re-examine our own values, create new common values, and move forward despite differing values. What is significant here is not that we as communicators become more objective with our message, but that our normative authority becomes more explicitly normative and less authoritarian. For this to

happen, as communicators we must be as willing to change our own views as we are wanting to change the views of those that we are communicating with, despite the fact that processes of personal transformation can be "uncomfortable, complex and time consuming" (Moore 2005, p. 84).

4 Limitations and Directions for Future Research

Developing the FST model was not without its challenges. When working with our first director, we were immediately confronted with the difficulties of the very different languages of art and science. It was only through a process of trial and error, and after we had developed our own identity and working-culture as scientist-actors that we learned to successfully communicate our expectations and needs to the theatre teachers that we worked with. Differences between the art and the scientific world should not be undermined. Bridging them involves a process of re-adjustment and a willingness to learn and be open to other perspectives, which is easier said than done as well as significant time investment. Another limitation to this model is that the communication effort can be considered as "preaching to the converted" in the sense that our audiences at academic sustainability conferences are usually of quite similar values regarding topics such as sustainability and climate change. However, the main purpose was not to persuade but to connect the rational and abstract to the emotional and personal, while maintaining a critical eye. I believe this model does address a specific need in academia for creating spaces for deliberation of values and self-reflectivity within research teams and within academia-policy collaboration, especially for those of us working in fields such as climate change, which carry heavy normative assumptions. The unique circumstances, which have allowed the FST to thrive—as a group of early career academics and practitioners with diverse cultural and disciplinary backgrounds—do not make this specific model necessarily replicable. However, it does invite consideration for further use of performative methods within sustainability in universities, be it as part of student-organised events, action-research projects or workshops for researchers themselves, particularly in the field of transdisciplinarity.

Further research is necessary to gain deeper insights of the potential of arts-based research for climate change communication and the specific mechanisms by which it can help to foster actionable knowledge. For instance, a different methodological approach including interviews and surveys may be necessary to provide empirical proof of the effect of performative methods on behavioural change of audience and actors. This raises challenges regarding the assessment of qualitative knowledge and the instrumentalisation of aesthetics. Questions of scalability and feasibility also need to be considered. However, there is no need to reinvent the wheel: many insights can be drawn from the disciplines of health and education where arts-based research has a longer trajectory. For this further studies that navigate disciplinary boundaries so that they are methodologically sound while still meaningful for other disciplines are necessary.

5 Conclusion

In the introduction of this paper we saw how research on climate change communication points towards the need for new communication formats which incorporate subjectivity and allow for deliberative processes that foster behavioural change. This paper explores the potential of performative methods as a way of achieving this.

In illustrating the experience of the Freiburg Scientific Theatre through an autoethnographic approach, we have seen how theatre can give us access to different ways of knowing beyond conventional science, find new approaches to problem solving, integrate different types of knowledge and perspectives, articulate them in a way that creates empathy and self-reflectivity in the audience, and create a platform for deliberation with the audience. The cultural diversity and transdisciplinary background of the group played an important role in capturing and articulating complexity, and the balancing of personal yet fictive narratives with humour were key in order to convey an authentic message that is credible yet inspiring. While the performances engaged the academic audience, the co-creative process carried the most transformative weight. The use of arts to communicate science opens up a discussion about how we define truth and what different forms of knowledge are possible and legitimate. This is a loaded question in the climate change communication arena, where scepticism towards climate change is seen as a major setback and obstacle to the purposes of the discipline. However, rather than limiting ourselves to persuasive communication methods, I suggest that performative methods offer valuable insights for designing effective deliberative spaces in which beliefs and values can be negotiated constructively.

This case study offers an example of how theatre can be used as a tool for communicating complex multi-dimensional topics such as climate change and sustainability in a way that connects to people's everyday lives. It reminds us that behavioural change is a process, not an event. It also points to the fact that as well as engaging the public as academics and practitioners—as "experts"—we might benefit by engaging in our own processes of self-reflectivity and deliberation amongst our peers. In order to transform the beliefs and world-views of society, we first have to be prepared to question our own belief systems and understand types of knowledge other than the scientific. In this context, universities can take an active role as a laboratory for new forms of epistemological integration.

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Watershed Discipleship: Communicating Climate Change Within a Christian Framework: A Case Study Analysis

Cherice Bock

1 Introduction: American Christians and Climate Change

The field of ecotheology articulates an environmental ethic based on the Christian worldview and sacred texts, but its influence on the values and behavior of the average American Christian is minimal. Christians in the United States are perhaps better known as climate deniers than as environmentalists, often holding an unhealthy anthropocentrism and dualistic view of humanity over nature (White 1967). Concurrently, Americans tend to be more religious than citizens of other developed nations, with 54% of Americans citing religion as important in their lives, compared to 24% of Canadians and 21% of Germans and Australians (Gao 2015). Yet, the Yale Program on Climate Change Communication (YPCCC 2016a) found that, of "global warming's six Americas" identified, the most "Alarmed" category has the lowest percentage of religious Americans (36%). The percent of religious in each category increases as the perceived threat of climate change lessens (48–68%). YPCCC (2016a) indicated that few Americans see global warming as a moral, spiritual, or religious issue. Communicating climate change as a religious or moral issue could heighten the importance Americans collectively place on it. Due to the high rate of consumption and waste by Americans, effective strategies for communicating with American religious about the dangers and necessity for action regarding climate change are crucial.

In an effort to decrease the negatively impactful consumption habits of this sizable demographic of Americans, the present study aims to educate climate change communicators about the rhetorical strategies found effective in communicating climate change to Christians, and provides a case study of practitioners who are successfully communicating climate change within the Christian framework while

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enacting pro-environmental behaviors. They call this emerging framework "watershed discipleship." Christians in the United States and elsewhere are encouraged to adopt the framework of watershed discipleship. Environmental activists and academics are encouraged to partner with churches and other faith communities such as those represented in this sample in order to utilize their built-in networks and constituencies and engage them in projects with positive environmental impacts.

This paper reviews the literature regarding effective communication strategies with Christians and barriers within the Christian narrative that keep Christians from readily engaging climate change. It then presents a case study detailing the practice of watershed discipleship, a framework that communicates climate change utilizing the rhetoric and symbols of Christian tradition, catalyzes pro-environmental behaviors, draws on knowledge of ecosystem services and social-ecological systems, and provides a platform for networks of environmental action within the local watershed. Reliant on Christian scripture and tradition, it could be adapted by any Christian community, holding particular promise in the United States where the percentage of religious individuals remains high.

2 Challenges and Possibilities in Communicating Climate Change to Christians: A Review of the Literature

Theologians have for decades recognized Western Christianity's complicity in upholding and justifying European conquest of the globe, with its resulting natural resource depletion, habitat degradation, and breakdown of essential ecosystem services, leading to human-caused climate change. As commonly interpreted, Christian theology communicates anthropocentric dominion and divine right to resources. In this hierarchical framework, human spirits are seen as the pinnacle of creation, while the material world is deemed less important. Some interpret the Bible's six-day creation literally, rejecting evolution. Many also understand God as all controlling, "probably" or "definitely" in control of the climate, so human beings cannot be the cause of global warming (YPCCC 2016b).

Ecotheologians interpret Christianity differently, recognizing the theme of care for the Earth within the tradition. The following metaphors, language, and rhetorical devices have been found effective in communicating environmental care to Christians (Marshall et al. 2016; Prelli and Winters 2009):

• Creator	• Healing	• Appeals to scientific authority
• Creation	• Garden	• Appeals to biblical authority
• Poverty	• Stewardship	• Vision
• Sin	• Reconciliation	• Transformation
• Limits	• Creation care	
• God as a designer	• Moral witnessing	

All five major faiths (Buddhism, Christianity, Hinduism, Islam, and Judaism) find the following metaphors and rhetorical devices helpful (Marshall et al. 2016):

- Earth as a precious gift
- Climate change as a moral challenge and disruption of natural balance
- Living faith through actions
- Taking a personal pledge

Lothes Biviano (2012) found Christian congregations most likely to actively engage environmentalism shared the following characteristics:

- A degree of scientific literacy
- Awareness of social, ecological, and environmental interconnectivity
- A commitment to social justice
- An expanding view of God and the moral universe that is able to include other species and the entirety of creation in its understanding of the Christian narrative

In short, Christians concerned about climate change use language and metaphors specific to their tradition, and are able to recognize, transmit, and enact an ecological paradigm within the framework of their tradition. Christians expressing this interpretation of their faith see care for the environment as a return to their tradition's core values (Lothes Biviano 2012; Myers 2010).

A growing body of literature outlines the theological importance of "creation care," but as Peterson (2007) stated, "There seems to be…little if any causal relationship between environmental value orientations, awareness, and concern, on the one hand, and behavior, on the other" (47). This is potentially a problem of misunderstanding the role of true communication. When ecotheologians use a transmission model of communication such as the Shannon-Weaver model, information is transferred from source to receiver, impacting the receiver's stated beliefs and values, but not necessarily his or her behavior (Cox 2006). An alternative model of communication posits that communication is about symbolic action. Instead of simply transmitting information, language and symbols "actively shape our understanding, create meaning, and orient us to a wider world" (Cox 2006, 20). This form of communication may catalyze progress on climate change mitigation.

Recent studies indicate that individuals given clear information about the scientific consensus on climate change shift toward belief in climate change (van der Linden et al. 2015), but a significant portion of American religious, "Religious Greens," though climate change believers, are not catalyzed to action (AP-NORC YSFES 2015). A framework communicating the scientific consensus on climate change, interpreting the Christian narrative to recover an ecological paradigm, and successfully transforming symbolic speech and ritual into action may engage many American Christians in pro-environmental behaviors. Therefore, two goals come to the fore in communicating climate change to Christians:

(1) Rhetoric: reinterpreting the Christian narrative to reclaim passages more in line with an ecological paradigm, and
(2) Symbolic action: translating liturgical rituals into pro-environmental behaviors.

3 Watershed Discipleship: A Case Study

This case study explores the communication strategies of those articulating watershed discipleship, an emerging framework that holds potential for communicating about climate change to Christians in a way that catalyzes pro-environmental behaviors. Preliminary research revealed that watershed discipleship practitioners are enacting pro-environmental behaviors based on their Christian faith and their knowledge of the problem of anthropogenic climate change. This study asked: What communication strategies are watershed discipleship practitioners utilizing in order to articulate a message about climate change within a Christian framework, and how does this move beyond rhetoric and symbols to motivate pro-environmental behaviors?

Watershed discipleship communicates climate change as a moral and religious issue, as the YPCCC (2016a) suggests. Education and awareness about environmental concerns are communicated using language meaningful to Christians, and practitioners of watershed discipleship reinterpret symbols and rituals, reclaim the ecological portions of their sacred narrative, and humbly learn the stories of their regions' land and people groups. They respond by working actively against injustice to land and people. Watershed discipleship is simultaneously a call to action and transformation.

In the pages that follow, watershed discipleship is defined, and the methods used to collect and analyze data in this case study are detailed. Results are shared, with examples of ways study participants communicate about climate change from a Christian framework. The discussion expands upon how these results address the two goals stated above, as well as similarities and differences between watershed discipleship and scholarly findings regarding effective climate change communication to Christians.

3.1 Definition

Ched Myers coined the term "watershed discipleship" around 2010, and he and Todd Wynward defined its "triple entendre":

- recognizing that we are in a watershed moment of crisis. Environmental and social justice and sustainability need to be integral to everything we do as inhabitants of specific places;

- acknowledging the bioregional locus of an incarnational following of Jesus. Our discipleship and the life of the local church inescapably take place in a watershed context;
- and implying…that we need to be disciples of our watersheds, learning from and recovenanting with the local "Book of Creation." (Myers 2016a, b, 9)

The first meaning provides a sense of urgency; the second utilizes Christian language of "incarnation" and "discipleship," combined with ecological terms such as "bioregional" and "watershed." Points two and three emphasize the need for embodied action in one's region. Focusing on the scalable concept of the watershed invites intimate understanding of the region one inhabits as well as a recognition of the interconnectivity of all watersheds. This rhetorical explanation of Christianity emphasizes social justice, being a disciple of Jesus, and living in a covenant relationship with the rest of creation based on faith in God. Liturgical rites serve as a catalyst to live out their faith through reinhabiting their watershed, getting to know its stories, people, places, and problems multi-dimensionally, including social, ecological, economic, and spiritual.

4 Methods

After identifying the gap between belief in ecotheology and enactment of pro-environmental behaviors among Christians, the researcher desired to identify a strategy for communicating climate change that could catalyze Christians to move beyond belief and into pro-environmental action. Encountering the term "watershed discipleship" through theological literature and professional connections, the researcher noted the individuals discussing watershed discipleship were engaged in pro-environmental behaviors at the levels of the individual, the community, and the ecosystem. To learn more about this framework and why it has the ability to mobilize Christians into pro-environmental behaviors, and in order to make the broader environmental community aware of the work of these Christian individuals and the organizations they work with, the researcher approached several individuals writing about and enacting watershed discipleship to consider participation in this study. The ensuing qualitative research study was a multiple case, intensive study explaining the phenomenon of watershed discipleship, and analyzing the communication strategies that make the framework effective in not only transmitting information, but also encouraging behavior change. Since watershed discipleship is an emerging framework that has not previously been explored in environmental literature outside of religious publications, conducting a case study analysis of individuals enacting this framework provides an in-depth look at the methods of communication used by some Christians to transmit information about climate change and to enact pro-environmental behaviors.

Six semi-structured interviews with practitioners of watershed discipleship form the heart of this case study, along with reviews of documents: published, unpublished, and forthcoming manuscripts, a sermon, writings used for liturgical

purposes, websites, a creek restoration guide, a video, promotional materials for events, and other documents provided by the study participants or found online. Participants were selected through reputation sampling, in that they are self-described practitioners of watershed discipleship, and most are publishing about that topic. Snowball sampling occurred: as the researcher began reaching out to potential participants, some of these recommended other participants. The six participants are those who responded to queries and were available for interviews in March–May 2016. Interviews ranged from 30 to 60 min, and were recorded and transcribed by the researcher. Four interviews took place on the phone, one via Skype, and one in person. 245 pages of interview transcripts and other documents were analyzed.

The collected data was coded using grounded theory methodology. The researcher performed an inductive, iterative analysis of the data, first noting keywords and concepts through open coding, then performing axial coding, finding patterns in the data in successive readings and analyses (Boeije 2010). Relationships between these patterns were identified, and ten themes emerged, which appear here in two categories pertinent to climate change communication: rhetoric and symbolic action. The codes and themes were then compared to extant literature regarding effective climate change communication with Christians. Member checking occurred as the researcher shared preliminary results and write-ups to the participants, and their feedback was incorporated into this paper.

Participants indicated informed consent of study participation, and chose to be identified by name so their work can be cited and others may find and collaborate with them: Katerina Friesen (Elkhart, IN), Jonathan McRay (Harrisonburg, VA), Ched Myers (Oak View, CA), Dave Pritchett (Portland, OR), Stuart Taylor (Elkin, NC), and Todd Wynward (Taos, NM). These individuals come from communities where watershed discipleship is being enacted across the United States Midwest, South, Southwest, and Northwest.

While this study holds promise in helping Christians in the United States and elsewhere articulate the moral dimensions of climate change and enact a more pro-environmental lifestyle, there are limitations. The six individuals whose words and actions were analyzed in this study are not representative of all Christians, or all American Christians. All participants identify as white, five out of six participants identify as male, all have bachelor's degrees and five out of six hold or are working on master's degrees, and most are members of or strongly influenced by peace churches (other denominations include Lutheran and Presbyterian). This case study represents the beliefs, actions, and communication strategies of these individuals, and as such cannot be generalized to the entire population of American Christians. It is hoped, however, that learning the stories and strategies of these individuals can provide a helpful framework for other Christians who want to communicate climate change in ways that encourage their communities toward pro-environmental behaviors. It is also hoped that this study can encourage environmental activists and practitioners to communicate more effectively with Christian communities espousing beliefs and practices similar to those in this study, forming partnerships for the benefit of their communities and the world.

5 Results

Analysis of the data revealed ten themes related to climate change communication, presented below in two categories based on the type of communication: rhetoric (eight themes) and symbolic action (two themes). Watershed discipleship practitioners utilize rhetorical strategies to reimagine, translate, and contextualize their received traditions, using personal experience and knowledge of social and environmental history and present context to inform what they find in the Christian scriptures. This informs their behavior toward other species and the natural world. They use symbols of liturgy and ritual to enact a place-based theology leading to watershed care, with a clear understanding that water flows across and through each watershed, connecting one to all.

5.1 Rhetoric

Theology itself is a form of rhetoric, as each generation of theologians deconstructs received dogma, finds the core message, and "remixes" tradition with current events to enact an old message in a new context (Daniels 2015). Ecotheologians perform rhetorical translation, but often simply transmit the way things should be ideally, with few or no entry points for putting ideas into action (Peterson 2007; Myers 2014a). This case study reveals ways watershed discipleship practitioners are utilizing innovative rhetorical strategies to communicate climate change in theological terms that lead to or are a reflection on practical action. Eight of these rhetorical strategies are discussed here: (i) praxis, (ii) recovering traditional ecological knowledge (TEK) and an ecological paradigm in scripture, (iii) learning social-ecological memories of their places, (iv) environmental justice, (v) re-placing and reinhabiting their watersheds, (vi) developing and sharing about an awareness of social-ecological systems and ecosystem services, (vii) speaking in biblical rhetorical styles, and (viii) use of Christian language.

(i) ***Praxis***. The praxis approach views theology as a reflection on lived experience combined with analysis of Christian scripture and tradition (Gutiérrez 1993). As watershed discipleship practitioners come to the text of their sacred scriptures, they recognize in it similarities to their own experience. For example, rather than reading the prophetic tirade of Isaiah 5 as an indictment against an ancient empire, Myers (2010) notes the similarity between the experience of the land and the poor in ancient Israel and in the present time. This works the other direction as well: noting the example of Jesus creating parables to understand God more clearly by using species such as flowers and birds found in his watershed, practitioners of watershed discipleship look for metaphors of God within their own watersheds (McRay 2014; Wynward 2014). Both directions require enactment: acting in the present context and interpreting the text through that lens, or hearing and responding to the call to action within the text.

(ii) ***Recovering TEK and an ecological paradigm in scripture***. In many cases, watershed discipleship practitioners are recovering the traditional ecological knowledge (TEK) present but ignored within the text of their sacred scriptures. An overarching theme ecotheologians are recovering regards the ecological implications of the practices of Sabbath and Jubilee, which encourage right relationship with one's community, land, animals, those outside one's community, and God (e.g., Myers 2010; Davis 2008; Brueggemann 2014; Wynward 2015; McRay 2014). Friesen (2014) connects watershed discipleship to the Hebrew concept of *shalom*, a holistic peace that invites humanity to live within the rhythms of the human and non-human systems they inhabit, and finds a similar concept in other indigenous knowledge bases (cf. Woodley 2012). Several of the case study participants mentioned Wendell Berry's rewording of the Golden Rule: "Do unto those downstream as you would have those upstream do unto you" (Berry 2004, 135; McRay 2014; Friesen 2014; Wynward 2015). This quote presents a key concept of Christianity, showing its compatibility with an ecological paradigm. In the reconstruction of Isaiah 5 mentioned above, Myers (2010) points out the prophet's knowledge of the land, agricultural practices, and knowledge about the ecology of a sustainable community in addition to social systems.

McRay (2014) notes echoes of an ecological paradigm in Jesus' words: "The good news of the kingdom of God could be interpreted as ecosynthesis, which is the evolution of native and exotic species into new ecosystems in response to novel conditions," and goes on to say, "perhaps Jesus' particular articulation of the kingdom of God was an imaginative patchwork of observation and interaction within an endlessly recreated, and recreating, place." He sees Jesus inviting his followers to "inhabit the transfigured Earth," to renew its social systems continually in order to maintain a healthy balance between social, ecological, and spiritual systems.

McRay (2014) also makes note of the Hebrew TEK of "circulation and grounding" of water, a recognition of the cycle of water between the heavens and earth and the need to store it in order to replenish the land in dry times. This contradicted the centralization and marginalization symbolized by aquifers and other imperial strategies that directed resources to the urban centers in the Ancient Near East and Roman world. Pritchett (Myers 2016a, b) notes a similar TEK in Jewish dietary practices, which helped Daniel and his friends resist the imperial strategy of resource centralization, and its inherent injustice to marginalized populations, when forced to live under the Babylonian Empire.

(iii) ***Learning social-ecological memories***. Watershed discipleship practitioners are also uncovering social-ecological memories present in the text and in their own watersheds. McRay (2014) reconstructs a passage from 2 Kings 5, presenting the Jordan River as an ecotone in the ecological sense as well as the fertile ground between ethnicities, genders, and social classes. Myers (2014b) discusses "redemption as rehydration" in the biblical prophets, and traces the importance of the hydrological cycle throughout the biblical

witness. He draws out the river of life in the book of Revelation, showing its power of renewal and rehydration, as opposed to the destruction that is typically emphasized in interpretations of this Apocalypse.

In addition to recovering TEK and social-ecological memories stored in sacred texts, practitioners of watershed discipleship are also attending to the social-ecological memories of the places in which they reside. They are learning how to be "good settlers" through building relationships with the native communities in their regions, learning about land management practices from pre-colonial times, and delving deeply into stories of human and ecological oppression and injustice that have been perpetrated on that land (Pritchett 2015; Friesen 2014; Myers 2014a; McRay 2014; Wynward 2015).

With this work comes acknowledgement of complicity in the systems that have created these injustices, including the Catholic Church's justification of European watershed conquest through a series of papal bulls in the 15th and 16th centuries. These collectively formed a legal and philosophical framework known as the Doctrine of Discovery, the purpose of which was to claim Western Christian sovereignty over indigenous lands and peoples (Friesen 2014; Pritchett 2015). This strand of Christian theology places an overemphasis on the spiritual to the detriment of the material, and holds an anthropocentric view of creation, giving humanity the divine right to the world's resources (Myers 2014a).

Watershed discipleship practitioners listen to the impact of these harmful theologies on real people and places and, through their writing and actions, acknowledge the harm these interpretations have done and speak against such interpretations. They offer alternative interpretations rooted in scripture, making note of the ecological paradigm out of which those texts speak. They attempt to humbly learn about the context and system of indigenous practices in their locales, avoiding cultural appropriation through practicing restorative justice and working on reconciliation.

(iv) ***Environmental justice***. A feedback loop develops as watershed discipleship practitioners learn about their area's history, become involved in restoration and adaptation projects, learn about the people and places around them, and reclaim and recreate places and communities (cf. Krasny and Tidball 2015). They often become environmental justice activists, citing social and environmental justice themes in the Bible. Friesen shared in her case study interview about a pilgrimage of lament and transformation she organized called a "Trail of Death," which follows the route of the 1838 forced removal of the Potawatomi people from northern Indiana and builds awareness of and solidarity with the Potawatomi people today. Taylor drew attention in his case study interview to the human and ecological injustices occurring with industrial chicken farms in his region, and he spoke about working with local stakeholders to combat negative impacts of this practice. McRay (2015) notes the breakdown in social and ecological systems due to systemic racism, leading to unjust incarceration and impoverishment of some communities of color in his region. He shared in his case study interview that he works

alongside community members to create safe housing for those recently released from incarceration, and he incorporates gardens and permaculture elements into under-utilized urban spaces such as alleyways, driveways, and parking lots.

(v) ***Re-placing and reinhabiting***. Myers' (2010, 2014a, b, 2016a, b) framing of watershed discipleship as a practice that follows the "incarnated" Christ, the one who became flesh to be in solidarity with humanity, invites active solidarity with those in our communities impacted by environmental degradation in an effort to create more holistic, reconciled relationships between all parties. He and others call this "re-place-ment" as they "reinhabit" their watersheds, with recognition that if one wants to be a disciple, it requires one's whole self including one's body: one must inhabit one's body and one's place in order to be a disciple of the one who became flesh to dwell among us (John 1:14). This interpretation leaves no room for a spiritualized belief system divorced from action. The action is the practice of discipleship, and takes place within the watershed in ways that contribute to the social, ecological, economic, and spiritual health of all within that shared space. They see the watershed as a nested part of the whole biosphere, so that, as McRay stated in his interview for this study, "tending to our place tends the world."

(vi) ***Social-ecological systems and ecosystem services***. Many of these practitioners mentioned developing greater awareness of their watersheds and seeking out opportunities to learn more about the ecological aspects of their regions. They also expressed clear understandings of the interconnectivity of social and ecological systems (cf. Biggs et al. 2015). "Reinhabiting" includes learning about and to live within the watershed's ecosystems, and to work for the health of these spaces. In his case study interview, McRay shared about his collaboration with local government agencies, universities, and community groups to create a watershed restoration manual for a community that had "largely been ignored when it comes to agricultural conservation work and flood mitigation" (McRay forthcoming). Myers shared in his interview that he serves on the Ventura Watershed Council and takes part in actions advocating for dam removal and restoration of the seasonal river's steelhead population, an act he thinks of as restorative justice. In Taylor's interview, he detailed his collaboration with a network of community partners using ecological practices to restore and mitigate natural and anthropogenic disturbances along local waterways. He created an organization called Watershed NOW, which instituted "Creek Week" in his community. They sponsor riparian restoration activities and watershed education in collaboration with public schools. He is also growing a network of vintners and tobacco farmers who, along with local artists and musicians, are holding education and fundraising events around watershed issues.

Case study participants recognize the interconnectivity of the social and ecological systems and their need for the ecosystem services they provide most often by talking about the ill health of these systems, or the need for reconciled

relationships between land, people groups, people and other species, and God. Myers stated in his interview that he situates his work "at the intersection of the seminary, the sanctuary, the streets, and the soil." In Pritchett's interview he said, "Healing is a long work, and we are where we are because of not one shattering event, but because of a long history of commodification of people and landscape: colonialism, degradation of soil. So it'll take at least as long to restore the landscape or make it whole in a new form."

(vii) ***Biblical rhetorical styles***. As practitioners of watershed discipleship recover the TEK within their faith tradition and learn the social-ecological narratives of their places, they translate back and forth between an ecological paradigm and Christian language. Although they claim the ecological paradigm is already present within the text, it has been co-opted by an imperial version of Christianity, which they and others term "Christendom" (McRay 2014; Friesen 2014; Myers 2016a, b; Wynward 2015). For Christianity to return to its core teachings, watershed discipleship practitioners argue, theology must be reclaimed as a holistic paradigm (Myers 2014a). They often choose to do so within rhetorical styles familiar to Christians. Friesen shared a "Prayer for the Tortured Earth" she wrote in the style of a psalm of lament. It invokes modern environmental and social justice crises, and uses language reminiscent of the Psalms, calling on God to "have mercy," to "come to our aid," and to "loose the Peace of Christ over all creation, from the foundations of the deep to Your heavens above."

Watershed discipleship practitioners also use the prophetic style. Biblical prophets held the tension between apocalyptic doom saying and visions of hope for the community, reminding of the intention behind the practices of the Jewish Torah or communal covenant with God. In his first written articulation of watershed discipleship, Myers (2010) reminded readers of the goal of the prophetic vocation: "speaking truth to power is *not* predicated on contempt, but upon *love*" (n.p., emphasis in the original). In that document, he went on to speak his own prophetic "love song." He explained the message and strategy of the prophet Isaiah, warning of the impending Israelite exile based on the injustices they were perpetrating against the poor and the land in breach of God's covenant, and inviting God's people to return to that covenant of love. Myers (2010) then utilized a similar prophetic form to express the peril of the current ecological crisis, expressing his deep love for the land and its people, and calling Christians to heal and reconcile relationships with God, land, and others.

As mentioned above in point (i) Praxis, watershed discipleship practitioners encourage Christians to emulate Jesus in his use of parables from natural metaphors. Wynward (2015) puts it thus:

> Think about how many times Jesus uses natural objects to illustrate his teachings: salt, light, mustard bushes, yeast, fish, figs, grapes, lilies, sheep, goats, cedars, palm trees, olives, mountains, rivers, sparrows, sand, stone, wheat, watering holes, ditches, donkeys, and many more. He was educating people about God and Spirit through nature. God's people

> have always paid attention to the wild world around them for holy education and divine direction. (81)

By pointing out the way Jesus and other biblical characters found God through parables based on the natural world, Wynward (2015) encourages people today to look at the "*oiko*," the home, basis for ecology and economy, in order to learn from its poisoned state about humanity's relationship with God, land, and others (80).

(viii) ***Christian language.*** Words such as Creator, creation, Spirit, spiritual, spirituality, incarnation, missions, atonement, forgiveness, conversion, confession, commissioning, communion, baptism, sacraments, healing, repentance, lament, salvation, redemption, reconciliation, and transformation occur in the collected data with frequency. The case study participants reinterpret creation as a gift, and remind Christians that the Bible discusses the whole of creation as part of the process of salvation and redemption (see especially Myers 2014b; Myers 2016a, b). They also utilize language that has become popular in some branches of Christian theology surrounding social justice, environmental justice, restorative justice, and liberation. All discuss the overarching problems of the global environmental crisis alongside the problems within the social system, and see the solution as reconciliation. They articulate an ecological metaphor where the planet's predicament is an illness in need of healing.

When writing for a Christian audience, watershed discipleship practitioners use stories and concepts from the Bible as examples from which to draw meaning and truth. They mention the Gospels and words of Jesus most frequently, followed by the prophetic texts. They also allude often to the Genesis stories of creation, the fall, and the flood, and utilize portions of the communal covenant described in the books of the Law. The book of Revelation gets quite a few mentions, and specific stories from the books of history form positive and negative examples. Not many references to the books of wisdom and poetry can be found in this data, and other than a section in Wynward (2015), no one mentions the book of Acts. Although the Acts of the Apostles follows the travels of some of Jesus' disciples and Paul, it is one of the most difficult portions of the Bible to bring into the watershed paradigm, since the disciples are intentionally going outside their watersheds to take the "good news" to the "ends of the earth" (Acts 1:8).

5.2 Symbolic Action

Many of the case study participants utilize the symbolic power of their ministry and reconciliation positions to preach, teach, and perform Christian rituals that point toward care of the watershed. They create new pieces for use in Christian liturgy, organize or join events enacting restoration and climate change mitigation strategies, and invite congregants to participate in long-term covenants to engage a more

sustainable lifestyle. The symbols of the liturgy encourage the enactment of pro-environmental behavior changes within and outside the church building through (ix) helping people move beyond debilitating responses to climate change such as fear and paralysis, and (x) localizing ingredients for Christian rites and practices.

(ix) ***Liturgical rhythms allow movement toward pro-environmental behavior***. Many individuals in American and other first-world cultures express grief and concern about climate change, but they do not know what to do, and the feelings become overwhelmingly paralyzing (Macy and Johnstone 2012). Christians have built-in liturgies expressing lament, confession, repentance, conversion, atonement, forgiveness, and reconciliation, and are caretakers of centuries of practice in helping individuals express and move past negative stages into a transformed life.

In her case study interview, Friesen expressed how the process of lament and repentance helps her reconcile with her watershed and gives her the strength to work for its healing:

> I often feel overwhelmed by all the problems globally, and that can become paralyzing and demoralizing. But when I connect here with my place—which I think is a way of connecting with all things everywhere—…when I connect with the oak trees here, the polluted water, the overuse of nitrates on farms, …and the native tribes that have been split and that once dwelled here on our land, …I'm able to tie lament to something real and not just abstract, like climate change, which is big and broad-scale…. To lament [is] a way of… learning the pain and moving with the pain. That's where the love can begin, by being connected to the pain in this place. So it teaches me about what suffering love looks like here, in the discipleship of Christ, which compels us to go into the suffering, knowing that it's not the end of the story. I think that's the story of the people of Christ as well as the biotic community in general….
>
> [I also think of] repentance, a turning away from destructive ways of being, and life, that the ecological crisis shows us that we've extended beyond our limits and we're on kind of the death train, and watershed discipleship is a way to turn around and not just say "no," but to say "yes" to something….
>
> "Reconciliation" [is] what we're moving towards, the goal: wholeness, connections between communities that have been broken, and through that, reconciliation with God that isn't divorced from reconciliation with community and the Earth.

Wynward shared about confession and atonement in his interview. In order to create more resilient ecosystems, it is necessary to acknowledge complicity in the problem. He said watershed discipleship "is a deep, profound atonement that's needed for being a perpetrator." To truly do the work of healing that needs to be done, especially for Europeans and European Americans, requires "dealing with land stealing and enslavement…and then atonement with native peoples whose land has been taken, and African Americans, who have been enslaved." As Christian communities engage in this work of restorative justice with people and the land, Wynward says this process of acknowledging and expressing our grief and guilt and working toward atonement and reconciliation provides an "antidote to despair." Working through this process of transformation helps him feel hope, even in the

midst of an ecological crisis that can otherwise seem overwhelming and discouraging:

> This idea of there being a sort of wild card, a God, who can give us the faith or hope to get through the day and not want to kill myself is pretty appealing. A lot of people I know are wanting to not deliver a baby into this world. They feel like it's a done deal, they're ready for the end of the world. But I think there's this moment of transformation that's still possible: there's this wild card of a God, this resurrection power. There's something in the Jesus narrative and this story of nonviolent power; there's something still in there.

Through liturgical rhythms, watershed discipleship practitioners are creating a space to acknowledge feelings of paralysis and impotence, complicity and repentance. These ritual spaces make grief allowable, and can provide names for and expressions of feelings of guilt and fear. The community can express these feelings, then move forward into an action that might help mitigate climate change in solidarity with their community. They enjoin disciples to repent, literally "turn around," and go a different direction, catalyzing a complete lifestyle change based in the narrative of the Christian tradition (see especially Friesen 2014; Wynward 2014, 2015). Through this process, reconciliation begins to occur on multiple levels, moving ecosystems, social systems, and spiritual communities into right relationship with God, i.e. health, wholeness, and *shalom*.

(x) ***Localizing the liturgy***. Performing Christian rites such as baptism and communion with attentiveness to place can help individuals connect with their place through meaningful practices. Myers (2014a) suggests Christians "localize the liturgy" (269), going out to local waters to perform baptisms, for example, or bringing local water into the sanctuary for ritual purposes. Taylor, in his case study interview, draws a connection between the water of baptism and the sacredness of all water, which serves a symbolic function throughout the Christian scriptures:

> When we do a baptism, we invoke various levels of biblical meaning in the water…from the creation story in Genesis, through waters of liberation in Exodus, to Jesus' own baptism in the River Jordan at the hands of John, to the final vision of the New Creation in Revelation 21 with the water flowing from the city of God around the Tree of Life. We invoke all those meanings of sacred water when we baptize.

The fact that baptisms cannot safely take place in many local rivers due to pollution can, if noted, be a wake-up call to the congregation to clean up the river (Pritchett 2014).

Friesen shared a sermon she preached, drawing out the overtones of a communion feast in the story of the Feeding of the 5000 (John 6), and showed how it fits within an ecological paradigm:

> Jesus explicitly tells the disciples *not* to go to the surrounding villages for food. All you need is right here – stay in this place, and God will provide. And then, suddenly, communion happens. Initiated by a peasant boy with a few loaves and fish to share, what we

> thought was reality suddenly shifts. Where the disciples saw scarcity, limitations and need, there is abundance, overflowing baskets and full bellies. [Emphasis in the original.]

Rather than thinking of communion as a mass-produced wafer alongside a grape beverage of unknown origin, communion can utilize elements from local producers and, drawing awareness through this symbolic rite to communion with God within one's watershed.

Since communion in its most original sense had to do with eating a meal together, Wynward's "25/75/100 Bioregional Food Covenant" suggests a daily act of communion within one's watershed. He invites everyone to commit to sourcing 75% of his or her food from a 100-mile radius by 2025 (Wynward 2014, 2015). The original covenant given to the Israelites in the Torah dealt with dietary laws that governed the relationships and health of people, animals, and land. Modern Christians can participate in a similar covenant expanding the liturgical act of communion into the everyday: an opportunity to commune with, or draw our awareness to the interconnectivity between, human beings, other species, the health of our places, and spirituality.

Conversion is also pinpointed as a liturgical symbol that can help communicate the type of action needed in response to climate change. In his case study interview, Wynward shared his purpose for his recent book: "With my book [*Rewilding the Way*], especially, and my work with outreach, I'm not trying to convince or convert people to Christianity, but to convert Christians to environmental life-ways." Acknowledging that first-world cultures are addicted to oil and its comforts, Wynward (2015) notes the similarities between the first three steps in Alcoholics Anonymous' Twelve Step Program: admitting the problem and one's powerless to solve it oneself, recognizing a higher power, turning one's will and life over to that higher power. This is what occurs within Christian conversion, and he invites Christians to deepen their conversion to include recognizing their addiction to the comforts borrowed from future generations through the use of fossil fuels. Instead, he suggests converting to reliance on God in a process he terms "rewilding," a willingness to engage with challenge and discomfort, to spend time in the wilderness as the Israelites and many prophets and holy men and women in the Bible and church history have done. Rather than attempting to "convert the land," as European missionaries and settlers did, watershed discipleship practitioners suggest conversion to the land, letting it teach about God to those who will listen (Myers 2016a, b).

And finally, watershed discipleship practitioners are reimagining the meaning of salvation, redemption, and the Great Commission. The text from Matthew 28 invites Jesus' followers to go into all the world, sharing about the "good news" of salvation Jesus proclaimed and baptizing people into their community. Friesen (2014) envisions a "mission home," an intention of rootedness to and love for a particular place. She mentions the "original trauma" of displacement experienced by many who moved to the United States, some against their will as slaves, others with few other options, such as Scotch-Irish fleeing the potato famine and consolidation of land in the hands of the wealthy, and others fleeing religious persecution. This original

trauma plays out by displacing others and abuse of the land. Recognizing that, according to the Christian scriptures, God reconciles all things to God's self and all creation is part of the story of salvation (Colossians 1:19–20, Romans 8:20–22), Friesen (2014) sees the act of learning to know, love, and act for the benefit of one's physical place as participation in the process of the salvation story.

Jesus' good news is for the poor, the captives, the blind, and the oppressed, and is a proclamation of a year of Jubilee, when debts are forgiven, land returns to its owners, slaves are freed of their indentured servitude, and the community resets its relationships, putting everything in its right place (Luke 4:18–19). Within this vision of Jesus' good news, care for the land determines one's right to the land, rather than ownership (McRay 2014). Recovering an ethic of land care within the gospel message, watershed discipleship practitioners commission Christians to care for their home places, and in so doing, to care for those downstream.

By explaining and practicing liturgical symbols and rituals through an ecological lens, and revealing the ecological lens already present in the Christian scriptures, watershed discipleship practitioners not only symbolically engage with their watersheds, but also actively learn about and practice embodied pro-environmental behaviors within their regions. Rituals move congregants beyond feelings of helplessness, despair, guilt, fear, paralysis, and apathy, providing entry points for Christians to engage in watershed care in ways that connect meaningfully with their faith tradition and reconcile them to people and ecosystems.

6 Discussion

Watershed discipleship addresses the two goals mentioned above: communicating the importance of environmental care within a Christian framework, and moving beyond rhetoric and symbols into lived pro-environmental behaviors to enact stated beliefs. It does this through engaging in an iterative communication strategy defined by liberation pedagogues as praxis, in which lived experience is reflected upon and informs theory, which propels individuals toward a new cycle of action, reflection, and theory-building. Without action, this process stalls, but watershed discipleship practitioners encourage meaningful action through activating Christians to take real pro-environmental steps within the bounds of their watershed.

Liturgical rites and processes, endowed with a narrative and history of meaning, allow the acknowledgement and release of negative emotions and offer small ways to begin the process of transformation into a new lifestyle. The liturgy can provide space for gathered communities to become aware of a problem such as complicity in climate change (conviction), acknowledge grief about the current ecological crisis (lament), express personal and collective misdeeds (confession), apologize and seek forgiveness, atone through change in actions and/or knowledge of God's act of atonement, and repent, or turn around to enact more pro-environmental behaviors, embarking on a process of transformation (sanctification).

For the practitioners in this study, denominational histories and emphases on social justice provide a natural segue into the topic of environmental justice, and once the connection is made between environmental health and social justice, individuals can begin to pick up on the ecological paradigm within their sacred teachings, understanding the interconnectivity between social and environmental systems. People of faith can add a spiritual dimension to the integrated social-ecological system, an added level of meaning that helps activate pro-environmental behaviors in those who hold the Christian story as sacred.

Although the denominational representation in this sample lacks diversity, participants mentioned working with people from many denominations, and other denominations are picking up the term. The Mountain States Mennonite Conference of Mennonite Church USA called Wynward to serve as a minister of watershed discipleship and has supported his initiative to launch a ten-year program to "Walk the Watershed Way" (Mennonite Creation Care Network 2014), but they are not the only ones moving in this direction. The Anglican Church of Canada (ACC) opened a "church plant/watershed discipleship community" in Vancouver, BC in 2015 (ACC 2015). The Evangelical Lutheran Church in America (ELCA) adopted a "resolution urging stewardship of the gift of water" at their general assembly in August 2016. They defined watershed discipleship and resolved to provide resources for each area to learn about their watershed districts, connect this with theological themes of water, learn to conserve and steward the "gift of these waters," and support those struggling with natural or human-caused water disasters (ELCA 2016). The Presbyterian Church USA encourages its members to practice watershed discipleship, and focused on this topic at their 2016 general assembly (Clark 2016). In the United Kingdom, theologian Michael Northcott (2012) is writing about a similar idea within European parish-based geography, which he terms "parochial ecology." The Universidad Biblica Latinoamericana in Costa Rica is currently translating a primer on watershed discipleship written by Myers into Spanish (Myers, personal communication). The concept of watershed discipleship is gaining traction.

Of the rhetoric and metaphors stated as important in Christian communities by Marshall et al. (2016) and Prelli and Winters (2009), those that arose as important in this study include Creator, creation, poverty, limits, healing, stewardship, reconciliation, creation care, moral witnessing (in the sense of a renewed vision of a "mission home"), seeking both scientific and biblical authority, vision, transformation, Earth as a precious gift, climate change as a moral issue, living faith through actions, and making a personal pledge.

These practitioners did not focus on the idea of God as designer of natural systems, and rarely mentioned the metaphor of the garden. They understand climate change as a disruption of a natural balance, but not with a desire to return to a prior ecological state. Instead, Pritchett (2015) discussed how Americans could be "good settlers," acknowledging that we cannot go back to some pristine state, and McRay (2015) suggested that through restorative justice, reconciled relationships can begin a healing process, continually creating ecosyntheses of new partnerships in novel contexts. All participants emphasized the importance of healing and reconciliation.

These metaphors express an ecological understanding that has moved beyond the equilibrium paradigm ecologists likewise discarded decades ago (Wu and Loucks 1995). Some Christians are drawn to the idea of an equilibrium state, where God directs all things toward one cosmic ordering, and they envision a return to an Edenic state, but many theologians highlight the creative, transformative, flowing nature of the Holy Spirit, an area of theology that provides ample connection points to an ecological paradigm (e.g. Ji-Sun Kim 2015; McFague 2008).

Notably scant in these documents are discussions of human sin. Sin is mentioned in passing regarding Christendom and colonialism from which Christians are in need of repentance (Friesen 2014; Myers 2016a, b; McRay 2014). Wynward (2015) hesitantly suggests the term "sin" as a descriptor of the actions of Americans who want to live within limits of the natural world, but find themselves unable to do so because of addiction to comfort. He assumes his audience will find the term "outdated, irrelevant, [and] laughable," though the sense of "missing the mark" he discusses would likely be palatable and recognizable to any relatively affluent individual who has attempted to live in a more environmentally friendly manner (Wynward 2015, 115–116). Some denominations may want to further develop the understanding of sin in watershed discipleship in order to adopt it as an acceptable Christian framework, and watershed discipleship practitioners could do further work in this area, perhaps drawing on the idea of collective or structural sin being developed by ecotheologians such as Cynthia Moe-Lobeda (2013). Some denominations also may not connect with the rhetoric of social justice. These denominations might change the language, as Marshall et al. (2016) suggest, to something like "fairness."

Watershed discipleship practitioners do align quite strongly with the types of Christians most likely to actively engage environmentalism identified by Lothes Biviano (2012). Each had scientific literacy, exhibited a high degree of awareness of the interconnectivity of social and ecological systems, were committed to social justice as an expression of their faith, and were continually seeking to learn more about God through learning from their watershed.

7 Conclusions

Watershed discipleship is currently practiced in the USA and Canada, with plans to translate the concept for implementation in Latin America, and a similar concept is emerging in the United Kingdom. Practitioners of watershed discipleship communicate climate change information and catalyze their constituents into pro-environmental behaviors utilizing various rhetorical strategies, including (i) an emphasis on praxis which includes action in addition to reflection and theory-building, (ii) finding resources within their sacred text regarding TEK from the indigenous Ancient Near East authors of the Bible, (iii) learning about social-ecological memories of their places, (iv) recognizing their own complicity in colonialism, racism, and other power hierarchies and standing instead for

environmental justice, (v) following the example of their "incarnated" God by "re-placing" themselves within their watersheds, (vi) learning and utilizing ecological language and paradigms such as ecosystem services and interconnectivity, (vii) speaking with the rhetorical styles used in the Bible such as prophecy, parables, psalms, and laments, and (viii) reorienting Christian language to connect environmental care to Christian faith.

In addition to utilizing these rhetorical strategies, watershed discipleship practitioners are also making use of their symbolic actions to draw attention to care for the planet. By creating space for lament about anthropogenic climate change, confession about complicity in it, and a framework for repentance (literally "turning around") from complicity into a transformed lifestyle, (ix) Christian liturgical rhythms are being repurposed to allow movement out of grief, despair, and guilt and toward hope and pro-environmental behavior change. Watershed discipleship practitioners are also finding ways to (x) localize the liturgy, using elements found in their watersheds for sacramental rituals. This encourages a connection of deep meaning to participants' watersheds, and provides a connection between Christian faith and place.

Watershed discipleship provides a moral framing of climate change with the potential to communicate the dangers of climate change to those American religious who as yet are less than alarmed about this issue (YPCCC 2016a). It utilizes many of the strategies identified by previous studies regarding what works in communicating climate change to Christians (Marshall et al. 2016; Prelli and Winters 2009; Lothes Biviano 2012). This framework overcomes the weakness of much ecotheology, that it is all talk and no action (Peterson 2007), through the eight rhetorical strategies found in the data, which combine Christian language and communication styles with unearthing an ecological paradigm deep in the core of the Christian tradition matched with current findings in ecology and climatology. By focusing on a unit of space, the watershed, which is small enough to be easily understood and actively engaged with, and yet scalable and connected to all watersheds, watershed discipleship practitioners invoke an intensely particular and yet universally applicable location in which action against climate change takes place. They make their watersheds a part of their rituals, and their rituals a part of the care of their watersheds.

Not only is watershed discipleship important for Christian communities, but it also has much to offer to the broader environmental movement. First, churches are often networked with other churches across the globe in denominational networks that can be tapped into as moral iterations of climate change mobilize churches. It is hoped that environmental groups can partner with churches to multiply pro-environmental behaviors through existing networks. Second, environmental groups currently lack spaces for liturgical rituals that could prove important for individuals who are stuck in feelings of guilt, grief, and denial (Macy and Johnstone 2012). As Christian communities adopt liturgical rhythms that include recognition of anthropogenic climate change, these spaces may help individuals move out of despair and apathy. Third, faith-based environmentalism is on the rise, and with it a stronger sense that personal and community-level pro-environmental behaviors can

make a difference. Communicating climate change to Christians in a way that connects with social justice and faith provides a strong base of meaning and moral fervor, a deep resource that has previously been applied in the United States to such issues as women's rights, abolition of slavery, and civil rights. That well runs deep, supporting activists through a narrative extending beyond their personal story into all generations of humanity, and potentially other species. This long-term vision and grounding is necessary for approaching the problem of climate change, which extends across many generations.

While this study holds promise in helping American Christians articulate the moral dimensions of climate change and enact a more pro-environmental lifestyle, the previously mentioned limitations regarding gender, educational status, race, and denomination should be taken into account. Since awareness of inequality, colonialism, and patriarchy are such important parts of the watershed discipleship framework, future research should include a wider demographic.

The current case study describes and explains the concept of watershed discipleship and how these six practitioners communicate and enact their beliefs about climate change from a Christian framework. Future research could draw from a larger sample through cross sectional or longitudinal studies of the pro-environmental behaviors of individuals and congregations engaged with watershed discipleship. Future studies could also explore partnerships between watershed discipleship communities and the environmental and civic groups in their regions, assessing the usefulness of churches as partners in climate change mitigation and adaptation strategies. Research on collective experiences of lament, confession, and repentance could also prove beneficial to the broader environmental movement. Are there ways to engage these ritual practices without connecting to a specific religious tradition? Might these rituals help individuals not involved in faith communities to access a longer-term vision that can help sustain them through the required prolonged struggle? Finally, future research could study whether communication strategies such as watershed discipleship can catalyze "Religious Greens" (AP-NORC YSFES 2015) from inert beliefs about climate change into active pro-environmental behaviors. This study focused on individuals who are already exhibiting these characteristics, but further study regarding the role of climate change communication in moving individuals and groups from belief into action would help practitioners more effectively engage people of faith in pro-environmental behaviors.

The framework of watershed discipleship could be applied in Christian communities anywhere in the world, and other spiritual traditions could (and are) engage in similar reinterpretation of their sacred scriptures with the desire to enact more pro-environmental behaviors. The denominations currently engaging with watershed discipleship are primarily peace churches and progressive mainline churches in the United States and Canada, and are mainly comprised of those who fit into the "Religious Green" category of the AP-NORC YSFES (2015) study. In that study, "Religious Greens" believed in climate change but did not exhibit many pro-environmental behaviors. It is hoped that through the practice of watershed discipleship, many Christians in the US and the world over can not only recognize

the problematic areas of some traditional articulations of their faith, but also utilize liturgical symbols in order to repent (turn around) and actively participate in incarnating their watersheds with practices leading to a healthy transition as the global community works to meet the challenge of anthropogenic climate change.

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Assessment of Outdoor Workers Perception Working in Extreme Hot Climate

Haruna Musa Moda and Abdullah Alshahrani

1 Introduction

The 2013 Intergovernmental Panel on Climate Change reported a rise in the mean global terrestrial and oceanic temperatures over the last 100 years (IPCC 2013). Recent epidemiology studies depict an increase in mortality and morbidity rates—specifically among people taking sensitive medication, suffering from chronic diseases or of elderly age, which could be attributed to extreme hot climates (Turner et al. 2012). In addition, groups at risk from extremely high temperatures are various sector workforces performing outdoor physical activities (Hanna et al. 2011). Exposure to extreme heat has been found to disturb internal body temperatures and can lead to heat induced illness at workplaces (Kjellstrom et al. 2010) and increase the risk level of occupational hazards (Schulte and Chun 2009) and reduced man-hour on the work to be done which in turn could affect economic productivity (Xiang et al. 2016).

The influence of high daily climatic temperatures is a concern, particularly in terms of increasing the risk of work-related injury and ill health (Knowlton et al. 2009; Kjellstrom et al. 2009; Ye et al. 2012; Lao et al. 2016; Li et al. 2016). Despite the concern, there is still great ambiguity in gauging the extent to which heat exposure is affecting workers on a population level and hence, the need to work towards acquiring evidence that can form the basis of developing heat-related regulations and guidelines, which can minimise work-related risks caused by heat exposure and help foster adaptation to changing climates. According to Sintunawa

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et al. (2009) there is lingering hypothesis proposing that people living in hotter climates can survive and adapt to increasing temperatures better. However, a sharp and sudden rise in temperatures can inhibit proper adaptation and increase mortality and morbidity rates especially among individuals with existing chronic condition as argued by Lin et al. (2013). This hypothesis resonates the scarcity of data related to climate changes in hot countries in the Middle East, and highlights the need for further research especially as it relate to the effects that increasing temperatures have on outdoor workers' health.

The impact of global climate change is reflected in the global temperature shifts and increased concentrations of atmospheric greenhouse gases (carbon dioxide and methane). The higher concentrations of greenhouse gases in the atmosphere have contributed to stratospheric cooling and triggered quick depletion of the stratospheric ozone layer causing larger volumes of ultraviolet radiation to enter the atmosphere (Keller 2007; Shindell et al. 2011) and the process has led to rise in the occurrence of fatal diseases (World Health Organisation 2008). This parallel rise in global radiation and diseases has stimulated scientists to consider the possibility of a relationship between the UV radiation and a number of increasingly prevalent diseases currently, experts are contemplating on a range of plausible factors including air pollution, agricultural productivity and changes in ultraviolet radiation (Leaf 1989; McMichael et al. 2003; Epstein 2005).

There are several risk factors for heat stress originating either from work process or from weather related. For instance, a worker's length of time within a physically challenging role has been highlighted as a risk factor for injury that include heat cramps caused by work or loss of fluids and electrolytes through excessive perspiration and sweat. Lin et al. (2013), have reported heat stress level as higher among certain outdoor work types (i.e. construction workers, road maintenance, miners etc.) and young workers are ranked higher at risk group from heat related injuries.

Heat related mortality and morbidity are preventable and strategies promoted to prevent these episodes include the use of engineering controls, administrative controls, personal protection, education and training are regulation enforcements (HSE 2013; Lin et al. 2013). Hence the need for all stakeholders to play key role in addressing its impact. In addition, past studies have considered different principles behind how individuals respond to extreme heat and conditions that are capable of impacting on outdoor workers health, comfort and performance (Parsons 2009; Petitti et al. 2013; Lin et al. 2013). To further prevent the impact of extreme heat strain among outdoor workers call for the implementation of these set of principles into guidelines and heat management systems.

In line with the awareness effort by HSE (2013) toward the reduction of health impact caused by extreme heat exposures, and the lack of enough study in this area especially in Jizan Saudi Arabia, the need for this study becomes important as a means of promoting heat stress management among outdoor workers within the construction industry that is at present experiencing high volume of work. This study examined individual perception around the impact of extreme heat among

construction workers in Jizan, Saudi Arabia caused by increased temperature and extreme heat exposure and response behaviour as it affect their morbidity.

2 Methodology

2.1 The Study Area

The company investigated is located in Jizan, Southwest of Saudi Arabia and part of the leading companies specialising in street lighting, asphalt, sidewalk and a wide range of construction activities. Initially founded as a Limited organisation in Jizan, the company from its earliest stages has contributed significantly to the construction and development sector in Saudi Arabia. Specifically, Jizan has a strong brand name in infrastructural development for villages and cities in various regions across Saudi Arabia. The region has average temperature of 30 °C and low latitude arid hot climate. Its climate during the summer months are hot and mild winter characterised by very humid condition and an average rainfall of 45–100 mm per year. The region runs along the Red Sea coast for almost 200 miles and at present, it is undergoing infrastructural development.

2.2 Research Design

The study explored the relationship between climate change and heat induced illness using a survey-based quantitative case study. The survey was the primary source of data collection, and comprised of six parts questionnaire comprising of 30 questions that aim to address different aspects of the research problem. Close-ended questions adopted in the study focused on adaptation strategy of workers on hot days; occupational heat exposure risk; heat-related illnesses and injuries experience; adaptation mechanism to manage extreme heat; facilitators and barriers to protective behaviour among the workers (Lao et al. 2016) and the questionnaire distributed among staff in the organisation.

To decrease the occurrence of bias in the selection process and to access wider coverage of participants for the study, participants were selected based on random sampling method. Participant inclusion criteria was based individuals that spend at least 5 h of their work outdoor. To promote the study, with the support of the site manager, intending participants were invited to take part in the study via the company internal mail distribution list and later 200 hard copies of the questionnaire was distributed and 110 (55%) were returned of which 10 were discarded due to non-completion. In addition, their consent to take part in the study was obtained prior to administering the questionnaire and to limit inference all participants were allowed to fill out their response at their free time.

2.3 Data Analysis

SPSS 21 was used for the data entry and validation Two variables ordinal and non-ordinal were considered during the data analysis and Mann-Whitney test, used to compare the difference between binary and ordinal variables (mainly due to issue of exposure). Furthermore, Chi-Square test was used to compare differences in the proportions between binary and non-ordinary variables. Kruskal-Wallis test one-way ANOVA was applied to determine significant differences among groups of independent variables or a continuum of dependent variables. To measure workers perception of extreme heat the following sets of variables were considered in the data analysis (1) adaptation strategy of workers on hot days (2) occupational heat exposure risk (3) heat-related illnesses and injuries experience (4) adaptation mechanism to manage extreme heat (5) facilitators and barriers to protective behaviour among the workers.

3 Results

3.1 Sample Description

Sample size considered in the analysis was 100 and all participants are male which was partly due to the nature of the work involved. From the group that took part in the study, 44% fall within the age group of 34–45, while 28% are in the 46–65 age range. More than one third of participants (37%) had between 6 and 10 years of work experience in the construction industry while 24% had less than 5 years of experience. The majority of the employees from the total sample (49%) came from an engineering background, followed by safety officers (27%), and labourers (18%). Furthermore, more than half of participants (54%) worked full time. Work pattern observed revealed that vast majority of the participants (91%) perform the work schedule during the day shifts, and more than two third participants (76%) had attended some form of safety training during their jobs.

3.2 Worker Exposure to Extreme Heat, Wellbeing and Productivity

Several factors potentially affect workers' personal levels of heat exposure and thermal discomfort. Respondents mentioned issues that include, extreme heat, use of personal protective equipment (PPE), task type undertaken, the work location, and access to shade and cold water. Considerable number of the participants (97%) in the study expressed heat exposure at work as major concern to their health, wellbeing and productivity. Fatigue was the major health concern expressed due the

Table 1 Participants response to selected heath induced symptoms (%)

	Never	Little	Moderately	Much	Mean	Rank
Sweat	22.0	33.0	18.0	27.0	2.50	4
Exhaustion	9.0	45.0	30.0	16.0	2.53	3
Rash	54.0	33.0	10.0	3.0	1.62	10
Fatigue	9.0	27.0	30.0	34.0	2.89	1
Fainting	61.0	24.0	12.0	3.0	1.57	11
Moodiness	30.0	15.0	31.0	24.0	2.49	5
Sleeplessness	21.0	42.0	28.0	9.0	2.25	6
Nausea	36.0	39.0	25.0	–	1.89	8
Dizziness	30.0	33.0	22.0	15.0	2.22	7
Headache	–	45.0	27.0	28.0	2.83	2
Cramps	45.0	39.0	10.0	6.0	1.77	9

Table 2 Comparison between foreign workers and their local counterparts around heat induced symptom caused by extreme heat exposure at work

	Nationality			
	Arab	Non-Arabic	Z	*p*-value
Sweat	2.00	1.00	−2.678	0.007
Exhaustion	2.00	3.00	−1.650	0.099
Rash	1.00	2.00	−4.968	0.000
Fatigue	2.00	4.00	−4.502	0.000
Fainting	1.00	2.00	−4.788	0.000
Moodiness	2.00	3.00	−4.862	0.000
Sleeplessness	3.00	2.00	−4.208	0.000
Nausea	1.00	2.00	−2.462	0.014
Dizziness	2.00	3.00	−4.533	0.000
Headache	2.00	4.00	−6.067	0.000
Cramps	1.00	2.00	−6.531-	0.000

effect of extreme heat exposure, with mean score of 2.89. It was noted that more half of the participants (34%) had much fatigue, whilst 30% had a moderate experience (Table 1). Headaches was the second most reported ill health among the participants, with mean score of 2.83. The participants believe long work under extreme heat is a major factor. Another impact is that of exhaustion while at work (2.53), and based on the survey result 16% said they experience much exhaustion during their shift hours.

Comparison of heat-induced symptoms with nationality is presented in Table 2. Based on the resulting median, the Arab participants generally tend to be less affected by symptoms compared with non-Arabic participants (p-value < 0.05). Symptoms reported include sweating, rashes, fainting, moodiness, sleeplessness, nausea, dizziness, and headache while age was considered an important factor in terms of heat exposure and the resultant impact of a higher tendency towards

experiencing the symptoms compared with other groups. Based on the participants' response the older workers are considered more vulnerable to the extreme weather condition.

By comparing the extreme heat symptoms between different age groups using median, the 56–65 years age group had a higher tendency of experiencing heat-induced symptoms compared with other groups. Furthermore, age groups other than the 56–65 manifested similar tendency results. The Kruskal-Wallis test showed significant difference (p-value < 0.05) between the age groups in terms of sweating, exhaustion, rash, fainting, moodiness, sleeplessness, nausea, dizziness, headache and cramps experienced. In addition, it was found that depending on the task undertaken and the time of the day working outdoor, the degree of heat felt by individuals does vary. However, there is a general opinion that work environment greatly affect the workers' health and work output especially where there are consecutive days of high temperature making both work tools and immediate environment become uncomfortably hot.

In terms of feeling any difference between heat levels of the past and the present while taking into consideration the length of years working for the company, 67% of the participants reported an increase of heat in the environment. The resultant effect as reported by 58% of the participants was that at some points they had become exhausted due to excessive heat exposure making task execution more difficult. The extreme heat was found to cause slow response rate to personal safety issues among the participants. As part of the general comment around the organisation heat policy where work is expected to stop when the temperature had reached certain degree and considered unbearable to work under. All respondents expressed said they have no knowledge on such policy in existence in the organisation. This findings call for review of the organisation work policy especially as it relate with outdoor workers safety. Personal safety and wellbeing awareness training was found to have a direct correlation between extreme heat exposure at work and ill heat induced due to heat exposure. From the findings of the study around two third of the participants (67%) said they make use of personal protection equipment (p-value = 0.042). However, the respondents perceived the use of personal protective clothing or equipment such as overall long sleeves uniform, helmets and gloves while working longer hours (5–8 h) as uncomfortable especially during the summer resulting in increased sweating which may cause mental and physical strain on them. This scenario has made some of the workers likely not to properly use their personal protective equipment (PPE) provided due to discomfort from the extreme heat.

3.3 Adaptation Strategy

Sherwood and Huber (2010) raised an important factor that need to be taken into consideration in terms limit to which individual could adapt to an extreme weather condition. Based on their work, clothing type, activity and acclimatisation can significantly impact on the adaptation strategy adopted by individual despite the use

of wet bulb globe temperature to quantify heat stress tolerance. Based on the present study, 37% of the participants stated their adaptation measures and wellbeing include start of work during the early morning hours and drinking lots of water. In terms of the amount of water intake only 30% reported as having an average of 5 l of water intake per day while at work. Key set back to their low water intake to rehydrate themselves was that, the water provision on site becomes too warm during the day and makes drinking less palatable. This further explain why some participants reported low amounts of water intake. Furthermore, participants that had experienced heat-related outcomes such as exhaustion and fatigue affirmed to a change in habits as a measure of avoiding further reoccurrence by taking breaks in between tasks. Although there was no mention of having any form of heat stress index on site (to prevent working over a set temperature) environmental temperature references were taken from the weather station data provided for the city. A key set back observed with this practice is that the immediate local ambient temperature could vary from that reported by the weather station. An onsite temperature monitoring system would be beneficial.

4 Discussion

To assess the impact of extreme heat on workers, data was collected on a range of aspects that include worker awareness on symptoms of heat stress and their frequency of experiencing the symptoms related to extreme heat exposure that included, but were not confined to cramps, fatigue, sweating, rashes, exhaustion and dizziness. Individual perceptions were assessed through tailored questions asked which allowed for the collection of data regarding extreme heat impact on occupational health. The majority of the heat-induced injuries or illnesses prevailed in hotter temperatures, specifically during summer months and during the warmest parts of the day (Bonauto et al. 2007). However, despite this widespread consent, there is still a lack of exploration on the link between extreme heat and various classes of heat-induced illnesses. In Australia, existing figures from Safe Work Australia (2011) depict that over a period of 11 years between 1997 and 2007, the total number of compensation claims filed due to environmental heat exposure was only 485. Similar results were seen in Washington, USA, where the number of compensation claims related to heat exposure was put at 480 over the 11 years between 1995 and 2005 (Bonauto et al. 2007). These relatively low statistics, it is evident that heat induced stress and illnesses are not given ample priority in occupational health especially in countries where they have weak implementation of safety standards. Nonetheless, if adequate prevention controls are applied in the affected workplaces, the risks associated with heat induced illnesses can be reduced immensely (Inaba and Mirbod 2007). Conducting risk assessment as it affect extreme heat exposure among outdoor workers will help prevent heat stress and other related illnesses. The study participant concern around the use of personal protective equipment (PPE) under extreme heat can be reduced if the workers are

encouraged to reduce time spent working under such condition. In addition, the provision of cool portable water supply on site will encourage fluid intake among these outwork.

Findings from the present survey depict that the most frequently reported heat illnesses included headaches, exhaustion, sweating and fatigue. Furthermore, there were also reports of workers experiencing dizziness and mood swings, which indicates the possibility of dehydration. Based on the data collected from the construction firm, it appears that work under extreme weather conditions contribute to increase dehydration level among the staff of which its severity has been highlighted in extant literature. Schulte et al. (2016) opined that, by taking part in outdoor work under extreme weather condition, for much longer period than necessary can affect the pace on the work and in the end could trigger mental fatigue, which could lead to increased risk of accidents. In their study, Knowlton et al. (2009) found that during the 2006 California heat wave, hospitalisations increased across a range of illnesses, including 11% increase in acute renal failure cases, 9% increase in imbalanced electrolyte cases, 5% increase in nephrotic syndrome, and a staggering 950% increase in heat-induced ailments. It is important to highlight that in the present study, it was noted that water intake for all affected workers was very low; highlighting the severe risks dehydration poses. Furthermore, The Institute of Medicine states that on average, a grown adult should consume at least 4 l of water per day in extreme heat conditions. However, result from the study revealed that more than half of the workers reported consuming less than 2 l of water per day at work, an amount far less than what was recommended in extreme heat conditions.

Considering extreme heat impact based on age group, there was a direct relationship between working temperatures and heat symptoms across the various groups. Previous studies on heat exposure and tolerance also emphasised that aged workers (especially more than 55 years) are most susceptible to outdoor illnesses from extreme heat conditions (Xiang et al. 2014a, b; Lao et al. 2016). In addition, Petitti et al. (2013) study reported that amongst US agricultural workers, elderly males have a higher risk of heat-induced deaths. Similar results were manifested in work conducted by Xiang et al. (2014a, b) during their study in South Australia.

Extreme heat and climate change can have variable impacts on workers' productivity. The data collected through the questionnaire indicates that worker productivity was indeed decreasing under intense working conditions. About half of the participants agreed that heat slowed their work down and thus has a direct impact on their productivity. Comprehensively, there was also consent that heat was affecting not only individual worker productivity but also the overall company productivity. As the outdoor temperatures continued to rise, efficiency and proactive behaviour declined. In some instances, workers tended to work longer hours in order to avoid peak heat periods while at the same time sticking to deadlines. However, in extreme temperatures (reaching 50 °C), many workers preferred to periodically stop work altogether. Extreme heat was considered a number one of the major reasons behind worker absenteeism (Zander et al. 2015). This decline in productivity also has a negative impact on the quality of work. This relationship between high temperatures and productivity is reflected in existing literature. For

example, Xiang et al. (2014a, b) and Lao et al. (2016) assessed the relationship between occupational injuries and high temperatures and reported a positive relationship between work injuries and high temperatures especially at temperatures above 38 °C.

Based on the survey information of the workers in the construction firm, the participants reported their productivity, as well as health had deteriorated primarily because of extreme heat since as they continue with outdoor related work activity. Furthermore, there was firm agreement among the workers (66%) that in recent years they have experienced a much hotter weather condition during their shift work especially in the daytime. Hence collaborating on the average increase in temperature in recent years reported earlier where under these condition it almost intolerable for workers to operate (Sherwood and Huber 2010). The nature of work required spending significant time outdoors, and rising average temperatures will magnify the intensity of heat faced by workers. Participating workers also stated that productivity does decrease with extreme heat. When the weather is too hot, workers tend to take more breaks and do less work to avoid over exertion. This can also be partially attributed to worker's willingness to complete the work on time, since a decline in productivity jeopardises their income and livelihood. In many cases, workers are forced to work overtime hours in extreme climates, compromising their health to avoid losing wages. Furthermore, the working hours are also long, ranging from five to eight hours of intense labour, and without any flexible offerings and lack of alternatives, there is little choice for workers other than working in the heat. Another concerning observation in the collected data was that one third of the workers were not using PPE partly due to increase heat when being worn. Although there was no mention of any adherence to recognised policy guide on work under extreme heat, based on the response provided by the participants there is need for explicit risk assessment and management in workplaces exposed to extreme heat, and to place staff welfare as a top priority to mitigate against further occupational exposure to extreme heat. In addition, the Labour and Workmen Law of the Kingdom of Saudi Arabia does place responsibility on the employers of labourers to ensure the safety and health of its workers and prevention of occupational diseases and injuries (Khasawneh 2014).

It is evident that the participants are susceptible to heat induced ailments exacerbated by either they have overlook the severe consequences of heat exposure or lacked proper awareness about them. Unfortunately, the small minority that did understand these risks also had a tendency to ignore them for different reasons. Hence, the need for a tailored training programme to address work site-specific condition will help improve this scenario. Accordingly Kjellstrom et al. (2009), raised concern for workforces in industries that are consistently exposed to extreme heats, and prone to be developing heat-related symptoms. The risks of heat-induced should be regarded as an important health issue in Saudi Arabia (Noweir et al. 1996; Noweir and Bafail 2008). Increase in extreme temperature exposure, coupled with a lack of flexible working condition and appropriate use of PPE to manage these risks can make workers prone to heat related illnesses.

5 Conclusion

There are limitations to the present study that should be take into consideration in the interpretation of the outcome and used as precursor to future study. Firstly, based on the limited size of the population in the study and focus one specific company, it is recommended that caution should be applied when extrapolating these findings in a different scenario. In addition, the overall participant that took part in the study are male to which both exposure rate and frequency of extreme heat exposure illness reported cannot be used to generalise similar trend among the female or mixed work force. Also considering that participation in the study was voluntary and individuals with experience may have been influenced by their experience to take part in the study there is the slight scenario such could have introduce biasness in their response. Finally, as the question was translated into Arabic during administering due to language barrier, this could have introduced some certain degree of misrepresentation of the theme of the questions. However, every effort has been made at ensuring that this does not happen and influence the study outcome.

The study explored the impact of climate change and extreme heat episodes on occupational health and safety in Saudi Arabia. It sought to provide findings derived from exploratory research conducted in a Saudi Arabian construction company and to offer these findings as a platform for theoretical development in future studies.

Findings from the study were able to confirm that the most prevalent heat related illnesses were headaches, exhaustion, sweating and fatigue. Furthermore, it was observed that water intake for the workers was very low, and this strengthened the association between heat exposure and work related injuries in Saudi Arabia. The older workforce group are considered more prone to heat related risks alongside workers that perform more extensive outdoor duties. The derived results also indicate that work productivity tends to decrease under extreme heat conditions. More than half of the participating workers affirm extreme heat has had great impact on their work output.

The research was limited in several aspects. The population size under consideration is minimal however the findings from the study did highlight several fundamental issues that would inform safe working policies, especially in countries such as Saudi Arabia that have extreme temperatures during the working day. There is a need to increase adequate and sufficient amenity provisions for the workers, such as availability of palatable water, enhance staff knowledge and awareness about prevention of heat stress, and improved work policy awareness around consideration of changing working patterns. In addition, effort should be made by placing emphasis on use of fluid replacement, refresher training, use of adequate personal protective equipment (PPE) and controlling high-risk activities in high-risk industries.

Furthermore, the study findings highlight the extent to which heat induced illnesses and its related problems are prevailing in hot climates and how the phenomenon is contributing to high morbidity rates. The relatively cost efficient

recommendations discussed above therefore can help enforce preventive measures against heath illnesses in the selected environment and can facilitate adaptation strategy in hot climate. In light of this, there is a need for in-depth research that can lead to contemporary policy development around occupational heat stress and its risks within the region in addition to understanding the psychosocial-managerial impact of heat exposure among outdoor workers.

To help door workers cope with extreme heat in Jizan, employers should consider work acclimatisation strategy where workers can gradually be introduced into the new job environment so doing it can help increase sweating efficiency. Furthermore, provision of potable water (>10 °C) onsite and encouraging staff to frequently rehydrate if undertaking energy demanding work will further help reduce mortality rate caused by extreme heat exposure. The need for planning and adequate management that does not only rely on risk reduction and education but also the need to develop work tailored strategy aim at reducing outdoor workers exposure to extreme heat and acclimatisation should be considered as a further means of addressing individual exposure to extreme heat condition among outdoor construction workers in Saudi Arabia.

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Games for Knowledge Transfer and as a Stimulus for Climate Change Mitigation in Agriculture—Lessons Learned from a Game Prototype

Anja Hansen, Kathrin Schneider and Johanna Lange

1 Introduction

The agricultural sector has been identified as source as well as a sink for greenhouse gases (GHG). In Germany for instance, approximately 7% of national GHG emissions—if expressed as carbon dioxide equivalents (CO_{2e})—are attributed to agricultural activities (Gniffke 2016). The most important contributions are those to nitrous oxide emissions (almost 80% of total German N_2O emissions; from fertilization of soils), and those to methane emissions (nearly 60% of total CH_4; livestock husbandry, manure management). Agriculture is as well one of those sectors that will be strongly affected by climate change itself, for instance through increasing number of extreme weather events (Smith et al. 2014), and changes in crop growth patterns (Prochnow et al. 2015). The agricultural sector in the stricter sense, such as farming activities and livestock husbandry, provides some options for GHG reductions at the farm level (BMEL 2008; Table 1). Other mitigation options exist for the sector in a wider sense along the supply chain, such as reductions of storage losses or reductions in animal product consumption (WBAE and WBW 2016). However, the latter are not the focus of this contribution.

Mitigation measures in agriculture affect complex functional chains, and consequently might have unintended effects within these chains: Though reduction in ruminant herd size reduces methane emissions, it might increase fossil CO_2

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Table 1 GHG mitigation options at the farm level (extended by authors, based on BMEL 2008)

Categories of farm level measures	Expected effect
Good agricultural practice	
• Soil probing	Demand-adapted fertilization
• Humus-conserving soil cultivation (straw return)	Soil fertility maintenance, reduced CO_2 emissions from humus degradation
Technical measures	
• Periodic maintenance of machines, for instance fertilization equipment	Uniform fertilizer distribution
• Precision farming	Adapted N-fertilization, herbicide reduction, yield increase
• Manure management (regular channel cleaning, storage covering)	Reduced methane losses
• Use of biofuels	Omission of fossil CO_2 emissions
• Use of residuals, for instance via carbonization	Fixing of biogenic carbon and soil improvement
• Fertilization technique	Reduced ammonia emissions (as N_2O precursor)
Management	
• No fertilization of turn space	Increased N efficiency
• Energy generation from manure	Reduced methane emissions
• Set-aside or re-wetting of organic soils	Re-fixation of atmospheric CO_2 in humus
• Reduction of herd size by increasing milk performance	Emission reduction per litre milk
• Fertilizer choice	Reduced emissions (lower emission factors, for instance 0.11% vs. 0.44% of applied N)
• Take a lead as prototype in village	Adoption of measures by neighbours
Animal keeping and feeding	
• Increased feed conversion (more concentrate and less roughage)	Milk yield increase
• Feed additives	Reduction methane from ruminants
• Extensive keeping systems of calves	Less emissions from concentrate production
Political & other measures	
• Vote for political party with a strong climate protection program	CC mitigation policies coming into force
• Use specialist counselling (for instance regarding biogas)	Potential implementation of mitigation measures
• Apply for public funding (for instance biogas generation)	Potential implementation of mitigation measures
• Reduce consumption of animal products yourself (as a farmer)	Slow demand-side changes on the agricultural markets

emissions because GHG credits from bioenergy generation dwindle. This effect is mediated by the reduced availability of manure as a feedstock for biogas plants.

Furthermore, agriculture is a sector where natural and human activities are intertwined, with the result that a clear allocation of emissions to different processes

is sometimes difficult. Similarly, involved substances interact, for instance in carbon and nitrogen cycles (Robertson et al. 2011; Soussana and Lemaire 2014). This complexity hampers an easy communication and transfer of CC mitigation strategies, further complicated by the need to account for site-specific diversity. Furthermore, farmers can and will adopt only those climate protection measures out of such lists that are economically feasible. For that reason, the LandPaKT (landpakt.atb-potsdam.de) project was initiated to identify farm-level measures that farmers might adopt, taking into account correlations between measures. Regional focus was Germany. Another goal was to identify policy measures that farmers might encourage to implement mitigation actions. The communication of the project content and results was tentatively realized with a card game (Fig. 1).

In agriculture, usual communication pathways of scientific results to the practitioner are: demonstration days and trade fairs, print media (brochures, journals, and books), specialist counselling and personal contacts in agricultural organizations. Transfer might be also realized during training in agricultural schools, even though to a small extent due to tight curricula. Regional differences exist in Germany how information is transferred.

First evidence on knowledge transfer in agriculture with science-based game approaches exist, for instance from García-Barrios et al. (2016). They demonstrated the potential of using games as a novel tool to better communicate the concept of ecological complexity (autonomous pest control in shade coffee) to students, farmers, resource managers, and policy makers. Besides such games for knowledge transfer, the broad public worldwide massively plays agent-based simulation models of land use ('Farmville', 'Happy Farm', or 'Farm Town', see Gonzalès et al. 2013), mainly for entertainment.

Against that background of complexity of CC mitigation in agriculture, this paper provides a short overview of serious (not for entertainment) games used for knowledge transfer, with a focus on climate change and agriculture. It analyses the suitability of such games to transfer mitigation and adaption knowledge to the actors of the agricultural sector. It infers some lessons learned from several occasions where a game prototype was played. These are briefly discussed against findings from a review on literature on serious games for knowledge transfer.

Fig.1 Representation and implementation of the uncertainty in climate change mitigation (left: biochar application to fields, high costs/unknown effect) versus fixed mitigation contribution (right: re-wetting of organic soils, low cost/large effect). Copyright 2016 by K. Schneider/author

The recommendations could be applicable also to other complex topics where games are considered as a way to communicate results and induce actions.

2 Serious Games for Knowledge Transfer

2.1 Application and Characteristics

Serious games as an option to educate, train and inform as well as to entertain have gained scientific interest in recent years, especially after publication of 'America's Army' (http://www.americasarmy.com/; published online by U.S. army for propaganda and recruitment) (Michael and Sande 2006). Already Huizinga (1944) discussed the apparent oxymoron of 'serious' and 'game'. Since then, serious games have been analysed especially in combination with computer games even though not exclusively. A main application sector of such games is the academic one (63%), whereas social change (14%), occupation (9%), health (8%), military (5%), and marketing sectors (1%) also make use of them (Ritterfeld and Ratan 2009). Hope has been stated that such games could help to communicate complex scientific concepts, as Chiarello and Castellano (2016) pointed out for board games on quantum mechanics, or for keeping science curiosity in students alive (Honey and Hilton 2011).

Serious games are essentially characterized by motivating goals, by structure providing rules, by no solitary entertainment focus, and by offering engagement opportunities in order to reach an optimum learning achievement. A feedback system is recommended as well as competitive components and some sort of conflict (Schneider 2016). These characteristics help players to immerse in the game ('feel the flow') (Csíkszentmihályi 2000).

2.2 Overview of Existing Serious Games with Regard to Climate Change and Agriculture

Robinson and Ausubel addressed climate change as a game topic already in 1983. Since then, several games have been published that deal with climate change for different target groups (see Table 1 in Wu and Lee 2015). One approach even used game making itself as a tool to communicate CC to students (Fung et al. 2015). Serious games cover a wide range of formats, as for instance offline facilitated experiences, card- or board games, online or offline computer games, mobile games, and pervasive games involving the use of multiple formats (Wu and Lee 2015). Table 2 presents some examples with special focus on games on climate change in combination with agriculture. These concentrate on CC mitigation and less on adaption. Just recently, Salvini et al. (2016) successfully applied a role

playing game approach for combined addressing of CC mitigation and adaption efforts for a study site in a deforested municipality in Brazil.

3 The LandPaKT Game Prototype

3.1 Development

The motivation for the game development was to introduce comprehensive project content to a broad public with the option to use it as well for later presentation of project results. The specific project LandPaKT (landpakt.atb-potsdam.de) integrated seven Ph.D. projects which addressed main aspects of CC mitigation on the farm level (re-wetting of organic soils, carbon sequestration in mineral soils, and livestock husbandry; see also Table 1).

A card game format was chosen for the prototype to present these CC mitigation measures in agriculture. From a literature survey, for some of the measures associated costs and specific CO_{2e} emission reductions could be derived. However, methodologies (system boundaries, considered GHG, modeling choices) were seldom comparable between references. Hence, most cost/benefit ratios of the different measures had to be guessed.

3.2 Storyline and Rules of the LandPaKT Game Prototype

In the LandPaKT game, the players take the role of farmers. With a restricted budget, they can choose a limited number of cards out of a catalogue of different CC mitigation options which have been grouped into five categories (see Table 1). Each measure is explained with a short note on each card with its mitigation effect not stated. Most of the measures have a price assigned; some are for free (see examples in Fig. 1).

Table 2 Games on climate change and agriculture

Name	Format	Focus group	References
Emission impossible	Online	Agricultural apprentices	OCCR (2012)
Sustainability game—learn how to feed the world through sustainable agricultural practices	Online	Students	Agrium Inc. (2014)
Industrial and food sovereignty playing cards	Cards	*not specified*	Grassroots International (2007)
The bioenergy farm game	Board game	Students	Great Lakes Bioenergy Research Center (2013)

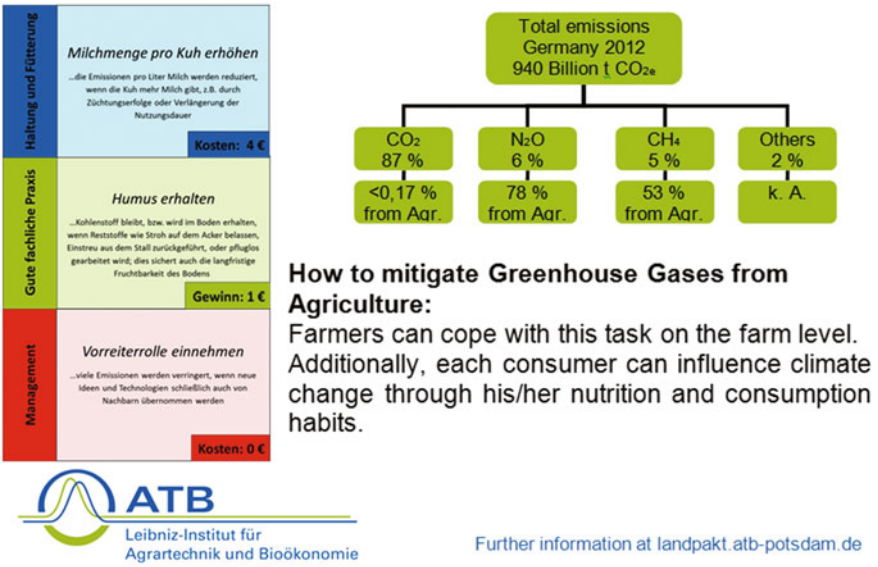

Fig. 2 Information card for take-away after playing (translated and enlarged reproduction, originally credit card-sized)

Depending on the players' know-how, a moderator describes the general concept of greenhouse gases and climate change, with specific information on agriculture. For this purpose, an illustrated poster is available. On demand, the moderator also explains contents of specific cards. The players take turns in choosing cards until their money is spent, or until they have collected the maximum number of cards, whatever happens first. In the following evaluation phase, each card's back is check for the mitigated CO_{2e} and summed up. For some cards, rolling the dice decides on the success of the specific measure. The player with the highest total mitigation sum wins. After the game, he/she can keep a credit card-sized chart which provides information on agriculture's contribution to national GHG emissions (Fig. 2).

3.3 Exemplary Application to Target Groups

The prototype with a first set of measures was introduced to the broad public in 2013 and onwards during different open events in the Metropolitan Area of Berlin, Germany ('Night/Day of Science'; LandPaKT 2013, 2014, 2015a, b). Interested lay people from age groups ranging from first grade students to senior citizens as well as agricultural students and farmers attended these events. Once, administration staff played the game (Hansen 2015). Over the years, the LandPaKT game was played approximately 100 times by various players (once only).

The CO_{2e} benefit/cost ratio and presentation of some measures were once revised and shortened to make the cards easier to understand. Whenever possible during events, we kept a tally which measures were the most frequently chosen. Even though a detailed statistical evaluation of these events does not exist, we would like to make some qualitative statements, in the light of a detailed literature survey on serious games for knowledge transfer.

4 Results—Feedback and Lessons Learned from Prototype Presentation

At the events, we experienced an intense demand for explaining climate change and GHG in general, and mitigation efforts in special, as well as basic agricultural activities. This absorbed some of the time available for the game. Nevertheless, no player abandoned the game, neither adult nor child. Almost two thirds of the time was spent with explanations and discussions of the different mitigation measures. After that, choosing mitigation measures cards and evaluating the results was quickly done. We found that the text-based explanations took up some time and consider revising them with a more visual graphical approach. However, this must be done cautiously, for instance following recommendations from Climate Outreach (2015).

From the available measures, players have frequently chosen 'humus-conserving soil cultivation'. This card was not only free of charge but generated additional income for the player (following the idea that soil fertility conservation pays back by increased or at least sustained yield levels). However, it has a low mitigation effect because only CO_2 emissions are affected. Another often chosen card was 'energy generation from manure' which directly reduces CH_4 emissions and furthermore gets credits for avoided fossil CO_2 emissions. Cards representing technology choices ('Maintenance', 'Precision Farming', 'Fertilizer choice') and soil-related cards ('Soil probing', 'Set-aside of organic soils') were selected with similar frequency. From the animal keeping category, a change from intense to extensive keeping systems raised the most interest. With the game played more often, one could identify those measures that might meet the most approval in the target group.

Success (i.e. victory) was not necessarily dependent on agricultural knowledge: Students from other disciplines occasionally outranked agricultural students; the high score was achieved by a child. Nevertheless, we consider it helpful to provide two different versions in the future, one for more advanced, that is adult players, and one for children that is more easily explained. Accounting for different knowledge levels was especially demanding when players in the same game differed from each other.

Especially after the revision of benefit/cost ratios of some of the measures, the random mitigation aspect superimposed the actively chosen effects, hence counteracted a successful learning impact. This indicates the need for another revision.

No best-case solution for CC mitigation in agriculture exists; accordingly, different strategies (husbandry-based, bioenergy-focused) might yield the highest mitigation results. A common question was "What should I have done differently?", and players were keen to know which mitigation the not-chosen cards would have provided. In short, we concluded that the aim of the game can be reached, that is to engage people with CC mitigation efforts in agriculture.

Still, several optimization potentials exist. The integration of additional events (for instance increase in CO_2 certificate prices as activity card), or a faster in-play feedback through immediate evaluation of mitigation effects from chosen cards might increase game-player interaction. The latter might also foster the learning effect for the relevance of the different greenhouse gases. If intensified identification with the game character 'farmer' is necessary, needs to be evaluated. Feedback of mitigation on adaptation efforts is not yet implemented. At present, the card set of measures consists of those mainly applicable to intensive agriculture, not for subsistence farming locations.

5 Discussion

Whereas game approaches are increasingly published, only a few have been found to specifically deal with communication of CC mitigation (or adaption) in agriculture.

Serious games have been applied in university education, for instance for teaching entrepreneurship to engineering students (Bellotti et al. 2014), or to communicate complex topics in physics (Chiarello and Castellano 2016). A number of papers advocate the integration of 'mass games' into scientific research, for instance for ecosystem service research (Costanza et al. 2014), land use change modelling (Gonzalès et al. 2013), or wildlife monitoring (Khelifa 2016). However, the latter has already been criticized for problematic aspects such as difficult evidence proof of species (Editorial 2016), or even conflicting effects as scaring rare species away (online comment to de Oliveira Roque 2016). A game approach helped to solve a capacity dilemma in Indian irrigation agriculture (Kimmich and Sagebiel 2016) and to support adaptation to climate change. Another approach helped to meaningfully communicate uncertainty in climate change to water managers and hence support adaptation processes to an uncertain future (van Pelt et al. 2015). An online game for educational of Swiss farming apprentices exists (OCCR 2012). German instructors saw sparse opportunities to implement such games into their schedule due to tight curricula (Anonymous 2015), whereas administrational staff expressed interest in implementation (personal communication). A board game that simulated complex ecological traits helped to communicate the cascading effects in autonomous pest control in a shade-coffee agroecosystem (García-Barrios et al. 2016).

Different game approaches have been used, among them games of influence (Courtois and Tazdaït 2007), social games (for communication of trade-offs between CC mitigation and adaption in urban planning; Juhola et al. 2013), or wicked games (as well in urban planning; Lundström et al. 2016). Role plays were used to check feasibility of managing coexistence of genetically modified and non GM-crops (Sausse et al. 2013).

Even though application of serious games approaches in environmental management increased, a standardized methodology for testing game effectiveness is still lacking (Johnson et al. 2017), as well as a centralized source for existing approaches (for instance in an online repository) (Madani et al. 2017).

The above collection of games used for communication and knowledge transfer cover a wide range of disciplines; however, they usually remained at the single case study level, and have not yet been adapted to other use cases. This might indicate that each discipline or topic needs special implementation into its own serious game.

6 Concluding Recommendations

In short, games were found to be a promising approach to get into a conversation on complex scientific topics with lay people as well as with stakeholders. Nevertheless, precautions are necessary to avoid frustration in players as well as in scientists who aim at knowledge transfer. The more complex the topic is the more effort must be put into game development including contribution from experts in that field. Games must consider prevalent knowledge as well as lack of knowledge. Scientists must be aware that there is no one-size-fits-all game version for a wide range of target groups, and consequently, that each game must be specifically adapted. This includes also regional-specific characteristics. The goal of the game must be precisely defined by the scientists prior to development.

Computer-based game approaches might offer opportunities to collect feedback from large numbers of players more easily. However, direct contact with game moderators allows integrating specific questions.

A multi-level approach is necessary to reach ambitious CC mitigation and adaption in agriculture. The approach could also include games for daily life (gamification; apps) as well as class-room fitting solutions that can be implemented in education curricula.

In the future, integration of scientific models with social media games might help to communicate and to identify CC mitigation measures that might find broad consensus. This applies not only to the agricultural sector in a narrow (farm) or wider sense (agricultural production chain down to the consumer), but as well to other sectors.

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Anja Hansen is a geo-ecologist who holds a diploma from the Technical University of Braunschweig. She has earned her Ph.D. in Agricultural Sciences from the Humboldt-Universität zu Berlin. From 2013–16, she coordinated a Leibniz-Association funded Graduate School. During that time, together with the members of that Graduate School (LandPaKT—Agricultural Techniques: Potentials and Costs of Greenhouse Gas Mitigation; landpakt.atb-potsdam.de), a card game was developed in order to support the transfer of project results to the public as well as to stakeholders. This game was analysed as a case study in the interdisciplinary MA thesis of Kathrin Schneider at the Technical University Berlin, for which Anja acted as a co-supervisor to Johanna Lange. Anja was a member of a German inter-federal state working group that came up with a methodological approach how GHG emissions should be consistently calculated on the farm level.

She is employed as a scientist since 2009 at the Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany where she is also responsible for the promotion of young researchers.

Kathrin Schneider The game was analysed as a case study in the interdisciplinary MA thesis of Kathrin Schneider at the Technical University Berlin, dealing with the potentials of serious games for knowledge transfer.

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Climate Impacts for German Schools—An Educational Web Portal Solution

Ines Blumenthal, Carolin Schlenther, Simon Hirsbrunner, Manfred Stock and Thomas Nocke

1 Introduction

Today's information- and knowledge-based society requires a direct dialogue between society and science (Schäfer et al. 2015). Through the internet, information is constantly available. However, it is only an individual who can demand, understand and evaluate it. The evaluation of information and messages is difficult. On one hand, the immense abundance of information through the new media formats can lead to disorientation and cognitive overload; on the other hand, information is sometimes obsolete, torn out of context, or simply wrong.

In dealing with the complexity of the available information, education plays a central role. For this reason, modern education in schools is competence-oriented, in other words, directed at everyday life. Students should be empowered to use

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information so that they can ultimately make reasoned decisions (Heymann 2004). Education must therefore always be re-calibrated.

In the specific case of climate change communication, various studies indicate that temporal and spatial distance is a barrier to the communication of climate change (Stoknes 2014; Pidgeon and Fischhoff 2011). As people perceive climate change as a phenomenon that takes place far away and in the future, they feel the issue of climate change less relevant than other current things (Raymond and Brown 2011). Teaching the aspects of climate change always means that teachers have to relate to the fundamentals of the subject. This is the only way for students to acquire the necessary competencies to orient themselves independently and to reflect on their own actions.

In practice however, there is a lack of methodological support, specialized material as well as suggestions on how to address complex scientific topics. In addition to the education and training of teachers, new insights into climate change are often not considered sufficiently. Teachers are on their own usually determining how to fill this gap and respond to urgent questions from students. For non-specialists it is a challenge to understand the complex subject of climate change. In addition, many of the current relevant research results remain hidden from the eyes of the layperson.

To enable teachers to better explain the complex relationship of climate change, its impacts on the society and available adaptation options, the educational online portal www.KlimafolgenOnline-Bildung.de was developed. It illustrates these effects in the case of Germany and provides first-hand research. This gives teachers and students the opportunity to explore scientific data on climate change down to the county level, which creates a strong regional connection. The rationale behind is to make the portal particularly interesting and practice-orientated, because the consequences of climate change can be reconstructed for the personal living environment.

The new educational web portal www.KlimafolgenOnline-Bildung.de is based on an existing tool (KlimafolgenOnline.com) which was launched in 2012 and developed for public sector decision makers to show the impacts of climate change in Germany. The new educational portal was designed by applying feedback from more than 40 teacher workshops. The findings were incorporated into a less technical, more self-explanatory, tailored solution for the use in German schools. Finally, it was evaluated by teacher workshops and a survey.

In order to use the portal and the learning modules correctly, teachers were trained in advanced training. Additionally, handouts, explanations and a tutorial were made available. Also, accompanying teaching materials were developed, which were tested and improved upon over the course of the project period. A total of 16 learning modules have been developed for interdisciplinary use in which the ecological and economic impacts of climate change are presented, for example, for agriculture, forestry, winter tourism and health. The “research workshops” (Lehrer-Online 2016), for example, help students to derive reasoned decisions for adaptation measures for different areas of life on the basis of the data organized in sectors.

However, the development and use of such a platform for teachers comes with a number of challenges that will be discussed in the course of this paper. First of all, scientific literature criticizes the lack of effectiveness of many existing climate impact platforms that do not account for the specific needs and characteristics of their target groups (Mitchel et al. 2016). To allow accessibility for students with different previous knowledge, experiences and capabilities, web portals by themselves also require a high level of plasticity (Walber 2005). Further challenges include the handling of scientific terminology and scientific visualizations for non-expert users, the communication of uncertainties and the integration of interactive web portals in school lessons in general.

The following paper provides a background of the developed solution (Section "Background"), describes the methodology (Section "Methodology"), the teachers' feedback from the workshops (Section "Teacher Worksh ops and Feedback Analysis"), the design and implementation process (Section "Design and Implementation of the Education Portal www.KlimafolgenOnline-Bildung.de"), the discussion and lessons learned from and with teachers (Section "Discussion and Lessons Learned"), and finally a conclusion and outlook (Section "Conclusions and Outlook").

2 Background

Web-based geo-platforms enjoy great popularity in the field of climate change communication and public engagement with science in general (Neset et al. 2016). The experiences gathered in the PIKee-project and literature on similar projects have shown that web portals provide great opportunities to present results of climate research processes and make it more tangible at the local level.

Web portals are also a great medium for conveying **media skills** within the curriculum. As media competencies are an integral part of the school subjects its methods are used in interdisciplinary projects to develop professional, social, methodical and media relevant competencies. For example, media pedagogy also contributes to the profiling of school concepts. At school, the focus is on the assessment of the media, the recognition and processing of media production and influence, the selection and use of media offerings and the design and distribution of own media products.

In Germany, the federal states are responsible for **education**. This means that the ministries of education of the 16 countries decide about the curricula. The development of curricula is a slow process. Therefore, in practice, there is often a large gap between current events and the school curriculum. A good example is the new curriculum of Berlin and Brandenburg, which was commissioned during the school year of 2011/12 to be implemented in 2017/18 (Bildungsserver Berlin-Brandenburg).

In 2007 a review of the "Orientation framework for the learning area of global development in the context of **Education for Sustainable Development**" (Siege and Schreiber 2015; United Nations 2016) provided federal states in Germany with a basis for the development of curricula and to offer concrete recommendations for

the inclusion of topics such as sustainable and global development. According to the guidelines of the federal states, there are references to various aspects of climate change in several subjects and for all age levels, from primary school to upper secondary level. Nevertheless, the implementation of the subjects ultimately depends in many cases on the personal commitment of teachers. In this context, the idea emerged of using the origins portal's potential for use in German schools.

Illustrating the foundation of this paper, Fig. 1 left depicts the user interface of the original web portal. Located on the top (left hand side) are the symbols representing the sectors for which data is provided: climate, agriculture, forestry, water, energy and miscellaneous. Each sector is associated with a bunch of parameters representing sector-specific data. For example, for the sector climate these are daily maximum temperature, precipitation or number of ice days, to name just a few. Once a specific sector is selected, the associated parameters appear along the top and more as part of a drop down-menu. In the navigation window on the right hand side the user can choose between the displayed average periods (30 yearly as the standard), seasonal visualizations, the Representative Concentration Pathways (RCP) scenarios, selected climate model runs and topographic navigational elements. At the bottom, a specific period in time can be chosen from the time scale to display the map data.

Figure 1 on the left also provides a first impression of the shortcomings of the graphical user interface design of the original portal. The small info box on the left hand side has proved too small to truly aid orientation. The color legend on the bottom left hand side can be easily overlooked. Also, the original portal offered two separate helping systems (one can be activated by the bottom left-hand side ('i') and the other by the top ('?')). This has been a constant cause for confusion as users found it hard to find the information they required.

Fig. 1 Screenshot of original climate impact tool with 30 year average as the standard setting (left); Screenshot of the redesigned education version www.KlimafolgenOnline-Bildung.de with 10 year average as the standard setting, presenting the new info box and colored pull-down menu (right)

In contrast, Fig. 1 right provides a first glimpse of the new, educational version www.KlimafolgenOnline-Bildung.de. Some of the new design elements are immediately noticeable. In the following sections, we will describe the process of its design and implementation.

3 Methodology

For the design and development of an educational climate impact web portal solution the following rationales were applied:

- Reducing entry barriers into the complex climate science topic for teacher and students
  - by reducing the complexity of climate science information (graphical user interface, terms, visualizations), evaluating simplified material by climate scientists
  - by developing multiple complexity levels for learning lessons for different classes and subjects
  - by developing easy-to-use learning units and tailored climate science background information
- Having intense practical seminars with trainee teachers
  - to test the interdisciplinary applicability of the original portal
  - to co-develop prototypic teaching units
- Conducting multiple workshops with teachers in several federal states
  - to test the applicability in heterogeneous curricula and to get feedback
  - to achieve a multiplier effect
- Strongly interlacing the individual process steps
  - to ensure a match between the design of the platform and the needs of teachers and students
  - to get immediate feedback loops
- Injecting impulses into climate (impact) science about the requirements in educational climate communication.

Based on this rationale the education portal development was designed using the following workflow:

1. *Curriculum/original portal analysis included*
   - Identification where the relevance of the topic fits to the needs of the existing curricula, including sustainable development (desktop analysis and stake holder discussions)

- Investigation into applicability for which subjects the original portal (Fig. 1 left) can be used, identifying first ideas for teaching units (four seminars of teacher trainings were held)

2. *Workshops with teachers*
   - Execution of workshops and interviews with teachers, students and environmental educators
   - Evaluation of the original platform and incorporating their feedback about the usability in terms of the interface, the design and background information for the development of the educational version
3. *Portal improvement/development of learning material & guidelines*
   - Redesign of the user interface and the scientific content to improve understanding for non-expert audiences
   - Development of data explanation and background information on scientific topics addressed by the platform
   - Elaboration of teaching modules providing structure and ideas for the usage of the platform in class [accounting for the institutional setting of the German educational system (curricula)]
   - Creation of a tutorial
4. *Validation workshops*
   - Evaluation of the platform in workshops with teachers
   - Implementation of adaptation measures and incorporation of feedback

To get a first impression of the usability of the original tool in schools, a desktop analysis of the general potential was performed and (pre-)tested with teachers and trainees. Building on these experiences, the development of the educational version has been set out as an intertwined process entailing intense trainee seminars, user evaluations with about 800 teachers, an adaptation and preparation part of scientific content, a redesign of the graphic user interface (GUI, see Fig. 1, right), and the elaboration of didactic material. The results of the teacher feedback sessions were collected and categorized. The most essential feedbacks were selected, evaluated and implemented.

4 Teacher Workshops and Feedback Analysis

In the first step, we conducted a desktop analysis of the general potential of map based climate impact web portals, which included the examination of relevant topics in different curricula. We found a broad field of potential interdisciplinary applications in school subjects: besides geography we identified biology, mathematics, English, German, philosophy, physics, computer science and others. In a second step we developed concrete ideas with trainees for concrete learning units.

In the third step, teachers were introduced into the original web portal solution, evaluated it and provided feedback in two formats: a survey and a discussion. In the survey, we asked about the applicability in teaching with an interdisciplinary perspective for their requirements about how to make it usable for teaching climate change impacts. We classified the feedback into three categories: portal design and graphical user interface changes, content changes including the data visualizations (maps and time series plot), portal content explanations and background related texts and videos, and missing issues and additional requirements. The feedback was analyzed and prioritized according to must-haves and nice-to-haves. Major results are summarized in Table 1.

One of the limitations was the design of the original user interface. Teachers suggested to reduce its overall complexity by simplifying the portal structure in general and to provide improved orientation and helping systems to cope with the complex information space of sectors, parameters, scenarios and time periods. In

Table 1 Collected demands from the workshops, ordered by their importance

Portal design and graphical user interface	Content	Additional requirements
• **Front page with introduction for using the portal** • **Reduction of duplications and reorder of menu items** • **Reduction of user interface complexities (e.g. two helping systems)** • **Simplification of the multitude of climate scenarios** • **Improvement of clarity in the representation of parameters**	• **Integration of tutorials for using the entire portal and understand the complexities** • **Reduction/simplification of scientific vocabulary** • **Improvement of parameter and sector background description** • **Clarification and simplification of parameter explanation and contextual information texts** • **Improvement of scenario explanation** • *Simplified interpretation of diagrams/graphics, including labels for the axis*	• *Development of several variants tailored for different grades, forms of schools and teachings* • *Usability for touch devices (smart phones, tablets and white boards)* • *Comparison with climate change impacts in other countries; data beyond Germany's border* • **Extraction of maps for further use on white boards** • Additional topographic information, urban centers, industrial regions**, forest or mountain layers** • **Comparison of two maps/ tables** • *Explicit interpretation of the spatial distribution and temporal trends of all physical parameters (e.g.: What are the consequences of more swimming days?)* • *Option for collaborative exchange between teachers and students (e.g. portal blog)*

Bold: implemented, plain: not implemented, cursive: implementation not possible due to technical or financial hurdles

this context they asked for the provision of an introductory element to the portal, which would describe the sectors and the possible settings. Further they suggested to reduce duplicate functionalities (two types of helping systems) and to re-order menu items. Teachers requested to re-organize the parameter selection lists, to reduce the multitude of presented climate scenarios and to simplify legends.

Plenty of feedback was gathered in regard to the **content of the web portal**. The main concern in this context was a clearer overall communication of the climate change message and the complex interrelationships. While the portal has a good data basis, the explanation of this data was conceived as too complicated, and a reduction of the scientific language was identified as a pressing issue. In particular, the teachers requested a better explanation of the meaning of physical parameters and their statistical aggregations, a clarification and extension of background information, for instance additional sector information, an improved explanation of the climate scenarios and climate model uncertainty explanations. Further, the teachers suggested to use tutorials as an explanatory element within the portal, and asked for a simplified and alphabetically organized glossary.

Additional requirements of teachers were syntactical and semantical descriptions of the maps and diagrams and labels for axes. An interesting feedback was that different variants of complexity for varying forms of schools, grade levels and teaching methods could strongly reduce the entrance barriers for younger students and teachers. To compare different visualizations or time periods directly, a portal side-by-side image comparison option was a further feature request. Some of these suggestions could not be realized due to budget constraints, but it was possible to offer some workaround options: users can make screenshots or open an additional browser window for the cross-examination of individual maps.

Beyond the web portal related feedback, more general **questions** related to climate change communication in schools were raised by teachers, including the following:

1. Where can information on climate change be found?
2. Which climate changes can be observed already today?
3. How certain are projections about climate change?
4. How can personal references to climate change be established?
5. How can options for action be shown?

5 Design and Implementation of the Education Portal www.KlimafolgenOnline-Bildung.de

The most essential suggestions from the teachers' workshops were implemented into the new educational portal. The reduction of complexity took place on two levels: graphical user interface re-design and its implementation by WetterOnline and the adaptation and extension of the portal content including the integration of

new media types. Due to convey and workshops it became apparent that most of the parameters of the original portal were interesting for the use in school. Particularly exciting, among others were the parameters presented in "miscellaneous" that shows indicator variables for the areas of health and tourism. It was therefore decided to show their parameters individually in the "health" and "tourism" sectors.

The Graphical user interface was re-designed by adding **(1)** a new orientation info box that integrates an overview of currently selected sector, parameter, model chain, time period, color legend with short explanations (Fig. 2 center). It provides entrance points to the **(2)** new hierarchically structured helping system (Fig. 2 left). The parameters within the portal have been organized by sectors and by topics (Fig. 2 center, right).

Users can now find all the parameters color coordinated (see Fig. 3) and organized in drop-down menus underneath their respective sectors (Fig. 3 top right). Each selected parameter is shortly explained in a new info box on the left hand side, which also improves the overall navigation of the portal (Fig. 2 center, and Fig. 3). In addition, we reduced the portal complexity in comparison to the original portal by now showing the median of the global climate models only (Fig. 2 right).

Following the teachers' feedback on the **content** side, the overall vocabulary of the portal was adapted to the educational requirements in secondary levels 1 and 2. Scientific terminology was reduced to enable an easier access to the topic of climate change impacts. For instance, the RCPs have been re-named as representing "weak

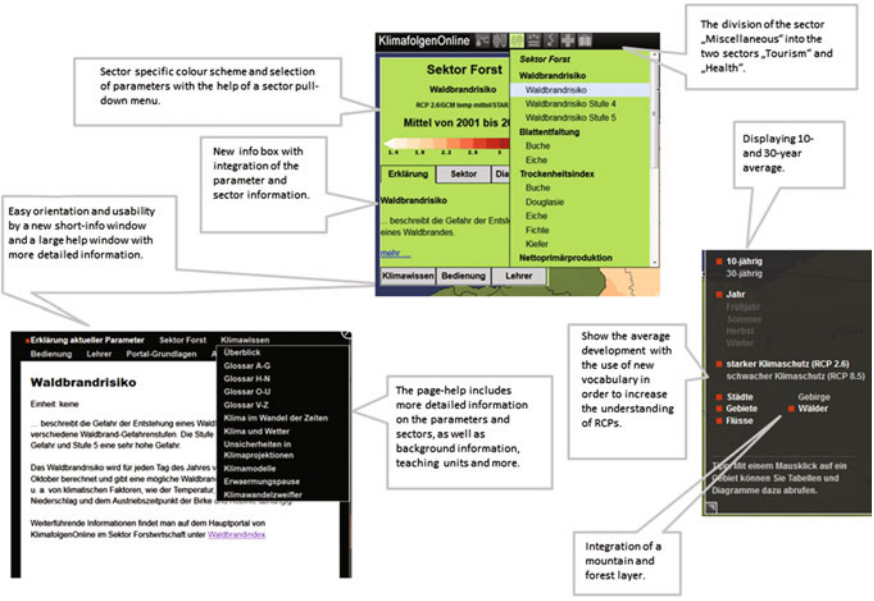

Fig. 2 Presentation of the improvements on www.KlimafolgenOnline-Bildung.de presenting new hierarchically structured helping system (left); color-orientated info box integrating an overview of selected sector, parameter, model chain, time period

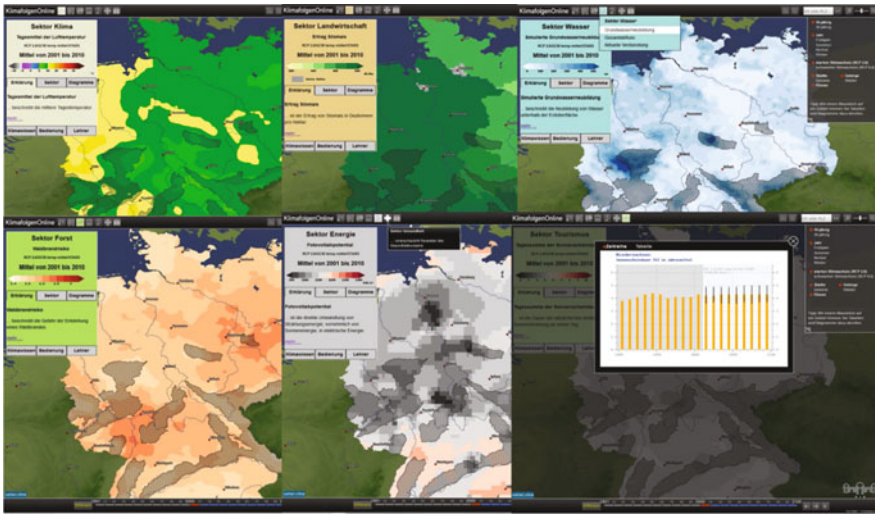

Fig. 3 Example for the color coordination of a selection of sectors (left); the drop-down menu for the sector water (top right); an example of a diagram within the sector tourism (bottom right)

climate protection" and "strong climate protection" in order to better communicate their meaning and increase understanding among users. This reduction process was done with tight incorporation of the domain scientists.

In order to cope with the uncertainties of future climate projections, further complexities of climate science, and the challenges these induce for school lessons, various textual teaching material and background information were conducted. The simplified and alphabetically organized glossary aids to understand the subject and explanations.

To provide an overview of the most important functions and how to navigate the portal, a tutorial (YouTube 2016) was created using an animated introduction video. This tutorial is intended to help all user groups to easier access the functions and contents of the portal. Furthermore, to provide answers to the general questions raised during the workshops (see previous section), we developed a general guidance (Blumenthal et al. 2016) how to deal with certain aspects of climate change communication. This guide is designed to encourage teachers of all disciplines communicating climate change and its effects without being an expert. There are hints where information can be obtained at different points and how best to communicate them.

In order to support teachers in using the portal a variety of 16 teaching units were developed. The six "research workshops" were designed for individual sectors and are available in three different levels of difficulty. These levels may apply to different school or competence levels among students. Teachers can choose the one appropriate for their students' abilities. The "research workshops" can either be used during regular lessons or within interdisciplinary project work. Other teaching

units are subject-specific. They have been designed for geography, but also for natural science subjects, mathematics or English lessons. All of the teaching units are presented within a dossier on the teachers' portal Lehrer-Online (Dossier) and freely available.

6 Discussion and Lessons Learned

The goal of developing the new educational portal www.KlimafolgenOnline-Bildung.de was to reduce the accessibility barriers by teachers and students. The workshops with teachers uncovered a number of challenges that teachers face in implementing digital media in their lessons. These workshops draw attention to the teachers' uncertainness of working with scientific information, existing limitations in scientific understanding and media competence. Climate denialists' arguments were also raised by the participants. Either teachers brought up the subject because they had doubts or they asked how to handle requests from the students.

Throughout the course of the development process the **gap between teachers and students** in regards to computer and media skills has become apparent. This gap has been pointed out by the teaching staff themselves, who recognized that so-called "digital native" students, who grew up with digital media, have an easier experience navigating the portal than teachers. The generational gap between 'digital natives' and 'digital immigrants' was particularly pronounced during a mixed feedback round attending students and teachers. While the students were adequately informed by the portal's tutorial and had figured out its functions by clicking their way through, the teachers expressed the wish for a day long workshop introducing the portal, its functions and potential uses. In connection with this observation is the issue of teachers showing a lack of confidence in front of their learners. The large gap in experience with digital media between students and teachers puts the latter in a position that only inhibits their confidence.

Teaching staff usually is under time pressure when preparing high quality lessons. **Time management** was an issue mentioned by teachers on many occasions as one of the reasons they shy away from using new media they are not confident in using. This especially applies to a portal communicating a scientific topic with an abundance of data, which is in some cases still controversial. Teachers may easily feel overwhelmed given their limited time availability.

Another concern by teachers was the low **level of attention span** of some students. They also mentioned that students can easily get bored when they cannot find the information they need and thus cannot advance in solving their task. The platform www.KlimafolgenOnline-Bildung.de offers a range of sectors and parameters, which students may feel tempted to explore. Additionally, some of the teaching units offered with the portal require the students to use external websites to gather supplementary information.

Teachers have repeatedly described how students showed difficulty in understanding the **practical applicability of the lessons** learned within school. They tend

to understand the content of their lessons as something that needs to be remembered for the next test, but see no practical use for it beyond school. Working with a portal like www.KlimafolgenOnline-Bildung.de, on the other hand, offers the chance to make that connection to the world beyond the classroom and illustrates that the knowledge conveyed within the lesson is of lifelong use and may well be applicable for the students' future careers. It also illustrates that the subject of climate change is no schoolbook theory, but one of the greatest challenges of our time, also in Germany, that an entire scientific field is dedicated towards solving.

Breaking down the science and **bridging the gap to the educational** sector was one of the biggest challenges. In order to communicate the science behind climate change and the most relevant topics within the climate science, background information was provided within the original portal. The aim was to keep the scientific truths, but to make it accessible for a young audience. This required the adaptation of large parts of the original portal's content and some of those have already been pointed out above, like the re-naming of the used RCPs or the use of the 10 year average as the standard setting in visualizing climate change. While in climate science the 30 time span is used for this purpose, time spans of this extent may overwhelm in the educational context. They may move the subject of climate change beyond students' conceivable imagination. This defeats the purpose of a portal designed to visualize that climate change is happening in the here and now.

The **challenge of complexity of terminology** is closely linked to the issue of target audiences. As the work with the original portal with teachers has shown, particular user groups require different degrees of information complexity. Moreover, these groups use different terminologies to express the same scientific facts and concepts. While experts in hydrology or agriculture would ask for high resolution data and to download datasets, lay people would require a translation of scientific facts into everyday language. A focus on adaptation challenges through the use of two climate scenarios is a good example for this. It clarifies the increase in challenges with every degree of global warming and draws attention towards the practical consequences of climate change.

To simplify the complex subject of climate change, glossary, tutorial and an easily accessible data explanation are using a lay person's language. Similarly, the tooltips give an easy to understand overview of the portal's elements and help the user to navigate. One of the teachers most favorite improvements is the reduction in parameters and their re-organization into sectoral categories. This re-structuring also helps to make the subject more accessible and aids an organized approach by the user.

7 Conclusion and Outlook

Within this paper, experiences and insights in designing and using an educational climate web platform in school lessons were presented. First of all, the new solution proved to be beneficial in closing the gap between the perceived spatial and

psychological distance to local climate change impacts. The inclusion of users on teachers and students has made it possible to provide tailor-made information, taking into account specific objectives, practices and institutional attitudes in the German education system.

The re-designed portal enables teachers to use a digital medium in the classroom by providing comprehensive information and additional support in teaching climate change. At the same time conveying of media competencies facilitates a self-evident use within the curriculum. Teachers have confirmed the interdisciplinary usability of the educational web portal, even though some barriers remain in the utilization of digital media within the school context and lack of knowledge about climate change. In order to reduce these barriers in terms of time management and media competence, it needs well-prepared material with little preparation time for the teacher. Furthermore, teachers should be given continuous training. For bridging attention span problems smaller-scale approaches will be developed in the future.

In summary, the educational portal www.KlimafolgenOnline-Bildung.de opens the door to a complex topic such as climate science. While many efforts of outreach have already been done by climate science, teachers have reported that it is still perceived as very detached. Thus, they welcome the opportunity to show students the topicality and practical appliance of the curricula with the help of the new web portal www.KlimafolgenOnline-Bildung.de.

For future work, the implementation of further suggestions from the teacher feedback, and a extension for students in vocational schools is planned. This will include a further reduction of complexity and a bunch of small teaching units, which will be guided by animated tutorials. Then we expect to inspire even more teachers using the portal in school.

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Communicating Climate Change in a Museum Setting—A Case Study

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1 Introduction

The topic of climate change and its associated impacts has been receiving ample attention in academic circles and media for quite some time now. However, despite all this attention, atmospheric concentrations of greenhouse gases (GHGs) are still on the rise (Pachauri et al. 2014). Although structural barriers such as low income, access to technology, and infrastructure influence necessary action against climate change, a great deal of inaction is due to the scientific message being lost in translation during the flow of information from researchers to the public (Gifford 2011). This has been highlighted in many surveys and opinion polls, which clearly show that the perception of the severity of climate change, i.e., its occurrence, threats and challenges for humankind, is relatively lower among the general public than among scientists (Capstick et al. 2015). In the United States for example, even though 87% of the scientific community considers climate change as anthropogenic, only about 50% of the general population views climate change as influenced by humans (Funk and Kennedy 2016).

Traditionally, a deficit model of communication is employed to relay climate related information to the public (Royal Society 1985). It follows the idea that providing laypersons with climate change knowledge would increase consensus and

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subsequent action. In this context, mass media has also emerged as a medium of climate change communication ever since the second Intergovernmental Panel on Climate Change (IPCC) report was published in 1995 (Salazar 2011). Although scientific information presented in mass media is easier to comprehend and more accessible than scientific literature, it suffers from some drawbacks. Studies suggest that a majority of the media outlets still rely on recycling scientific knowledge leading to a saturation of information and lack of public engagement (Salazar 2011).

Thus, this conventional linear transfer of knowledge from experts to the public has been found wanting. Recent studies urge climate change researchers and experts to move away from this mode of one way communication towards more reflexive and engaging methods (Ockwell et al. 2009). While non-traditional channels of communication, such as blogs or social media, show promise in this regard, they have received less attention in the climate change communication discourse (Koteyko et al. 2010). This highlights the need to explore new avenues for communicating climate change among the masses. In this study, we explore the possibility of remodelling a conventional form of scientific communication, namely a museum exhibition, to be used as a platform to communicate climate change.

Museums have been traditional hotbeds of scientific exchange (Greenhill 1992). They hold a unique position as a trusted information source that enables open dialogue and social interactions. Through the years, museums have reinvented themselves in the context of emerging social, economic and environmental issues (Kelly 2006). Recent literature suggests that museums are also emerging as key information sources in communicating climate change (Cameron and Deslandes 2011; Cameron et al. 2013; Salazar 2011). The ability of museums to engage visitors through sensory, affective and immersive experiences renders them unique in reinforcing climate change narratives (Cameron et al. 2013). Hence, the potential of museums to serve as a forum for climate change communication is clear. Acknowledging this potential, an exhibition was designed and developed to communicate and engage the public (with a particular focus on young people) on the science of climate change, its impacts and possible solutions to avert its dangers.

This paper identifies, based on a case study, possible drivers and barriers for a successful communication of climate change in a museum setting. The insights gained should aid similar future endeavours in communicating a topic, which is complicated, uncertain and politically loaded. The paper describes the exhibition and its development process including challenges faced during the scientific design and implementation. It also discusses experiences from working in an interdisciplinary team and by engaging with the public on climate change. The findings, even though backed up by literature, are mainly based on experiences made by the authors themselves, by discussing related questions with other members of the exhibition team, and feedback from visitors during the exhibition.

2 CliMatters: A Museum Exhibition on Climate Change

The exhibition was developed by a group of faculty and students from the Doctoral Programme Climate Change[1] at the University of Graz, Austria. The team was further supported by faculty from the Institute of Philosophy and designers from the University of Graz. The expertise in the team encompassed humanities, social and natural sciences, and also visual design and architecture. This multi- and interdisciplinary team setting of 13 people bode well in addressing the issue of climate change, which requires insights and inputs from various fields of expertise. The rationale behind the team composition was to draw knowledge and skills from various disciplines and collaborate to communicate the science of climate change, its impacts and solutions to combat its dangers. The objective was to create and spread awareness about climate change especially among young people (mainly aged 10 to 18) through participation, interaction, and illustrative media. This goal was reflected in the exhibition title "KliMacht | CliMatters", which appealed for mindfulness ("Acht"samkeit in German) regarding actions of individuals as to climate change and implied that all our actions "matter". All researchers had a thorough understanding of the science, impacts and opportunities related to climate change with respect to their individual fields. Such a varied and interdisciplinary group was able to cover more ground not only limited to scientific knowledge, but also with respect to communication of this knowledge. While there are many channels to communicate any scientific topic, the group decided to use a museum as a platform to implement their ideas. Initial ideas revolved around traveling information booths, climate activism projects, focus groups, and movie screenings. However, the museum had a broader appeal since it would allow combining all the ideas listed above in one space. The museum also allowed for a consistent and interactive narrative to illustrate the topic.

The scientific design and development of the exhibition were carried out in various steps. At the beginning, the team decided on an overall narrative for the exhibition, which was shaped in iterative group meetings (details of the encompassed topics are described in Section "Overview of the Exhibition"). The next step involved choosing a target audience. Research has indicated that young people are often well versed about the dangers of climate change. However, the basic concepts related to climate science, dealing with uncertainties, and potential of mitigation options to combat climate change remain unclear (Corner et al. 2015). Additionally, there are two factors that render young people unique in the climate change arena. Firstly, young people are relatively more vulnerable to the impacts of climate change as compared to older generations. Nevertheless, they also have the opportunity to determine the near and long term responses to curb the dangers of climate change (Corner et al. 2015). Understanding this importance, the exhibition primarily targeted to appeal and communicate to the youth.

[1] http://dk-climate-change.uni-graz.at/en/.

After determining the target audience, ideas regarding exhibits were generated and evaluated as to whether they fit the overall narrative. The specific exhibit ideas were developed further by individual researchers, based on their interest and expertise and honed through a scientific and design based vetting process. The interdisciplinary expertise within the group greatly helped in this regard. The design team suggested using an "activating" design drawing upon state-of-the-art knowledge from psychology and educational sciences about senses, sensuality and the importance of emotions and feelings. This helped in the design of appropriate visual communication strategies to translate scientific data into concrete experiences. Consequently, a strong emphasis was put on veering away from the academic rhetoric of scientific communication by developing an exhibition which features games, experiments and interactive media to engage visitors.

While each member was responsible for his or her exhibits (including background research, design, visualisation and write ups of wall charts and catalogue texts), ideas and texts were circulated among all members and checked for consistency and other edits. Each member also communicated closely with the design team to account for visualisation, consistency with other exhibits and the final implementation. This collaborative effort led to the design and final selection of 30 exhibits which were displayed at the museum. The exhibition was on display from March to June 2016 at the UniGraz@Museum[2] and visited by about 1500 people.

During guided tours, the researchers observed that the visitors' responses to individual exhibits differed from what was expected (e.g., particular strong interest, neglect, or incomprehension of certain exhibits). This rose the question for the causes and stimulated discussions within the team, which led, together with the study of additional relevant literature, to assumptions and reasons, as to why some exhibits worked out as intended or even better, while others did not. This paper details and reflects in Section "Drivers and Barriers to Successful Communication" these experiences. These insights should aid researchers faced with similar challenges in communicating climate change.

3 Overview of the Exhibition

The exhibition narrative was broadly categorised into five sections, as illustrated in Fig. 1, and the exhibition space, a rectangular hallway, helped visitors follow it.

While the exhibition narrative was developed from scientific information, the visual design was influenced by two historic art movements. The Bauhaus principles, a reductionist design, were employed using mainly primary colours and geometric shapes. Yellow represented the current climate, red a possible worst-case scenario, and blue an ideal scenario where climate change is mitigated. The colours along with the exhibition space were used as a self-explanatory guiding system

[2] http://unigraz-at-museum.uni-graz.at.

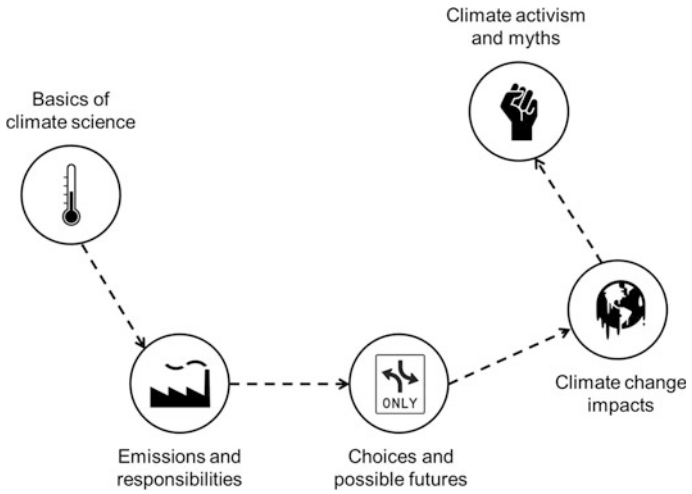

Fig. 1 Museum concept and narrative

throughout the exhibition, represented by coloured lines on the floor. Russian revolutionary art served as basis for the design as it denotes the need for "revolutionary action" to mitigate climate change, including cognitive and behavioral changes. The narrative was further strengthened by the use of materials with an "ecological message", such as recycled cardboards for wall charts.

The sections along with the constituent exhibits (for pictures of the exhibits see Fig. 2) are discussed below.

3.1 The Basics of Climate Change

The opening exhibit of the exhibition was the "*temperature wall*". The exhibit, driven by climate model data, illustrated the evolution of temperature in Austria from 1850 to 2100. For the future, the curve split into two parts, each one representing a plausible future scenario (representative concentration pathways RCP 2.6 and 8.5; Meinshausen et al. 2011). The exhibit also included short descriptions of facts and events related to climate research along the temperature curve, represented by small flags. Colour coding was used as outlined in the previous section to guide users to the impacts of following either of these two future scenarios (red and blue rooms respectively, see Section "Individual Choices and Two Possible Futures").

The exhibit also picked up selected topics related to uncertainties in climate research. It showed how research can address uncertainty of future conditions using different scenarios and how statistics can help to deal with data uncertainty, e.g., by averaging over multiple model simulations. A "*fall experiment*" was added, where

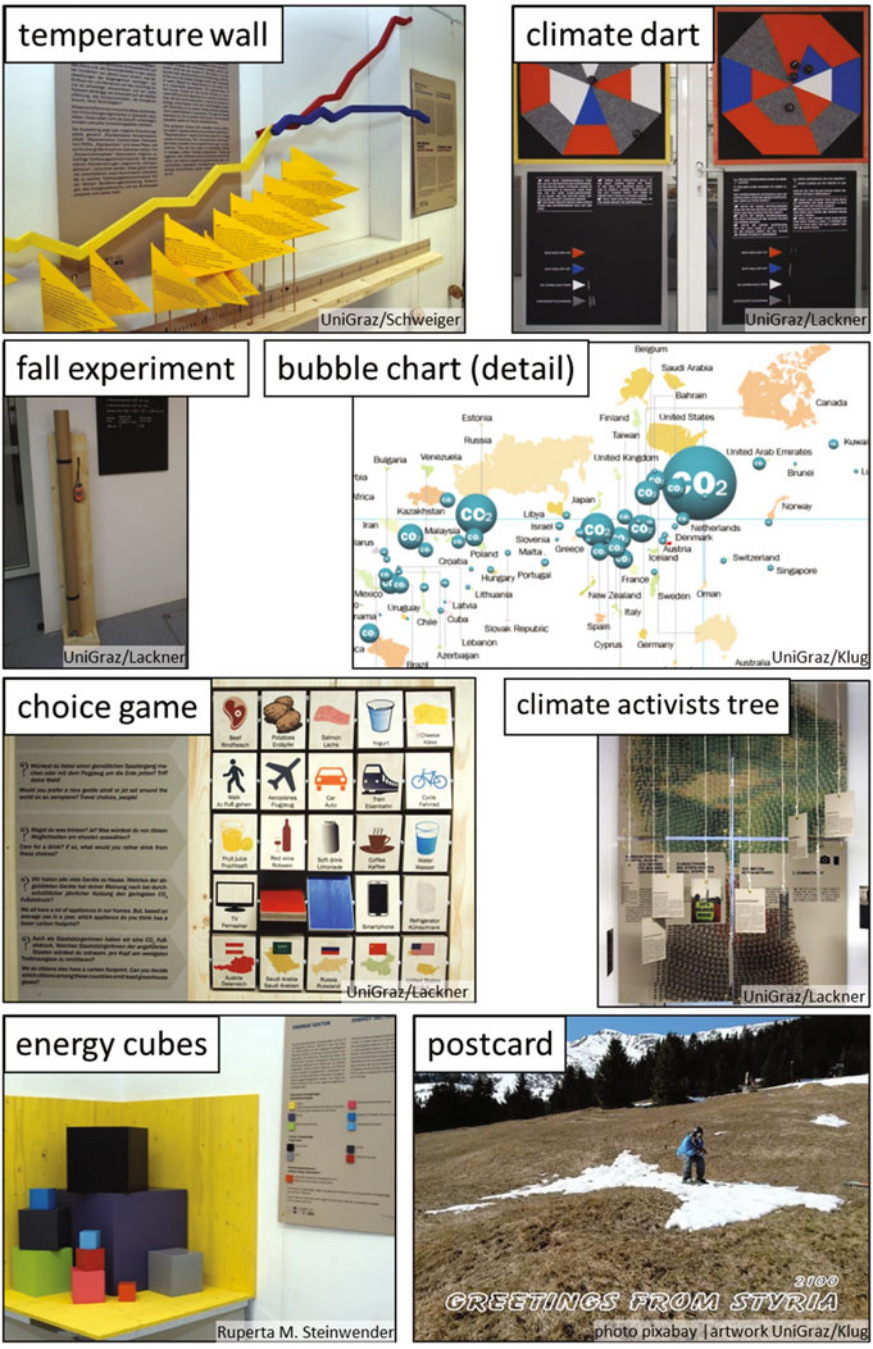

Fig. 2 Selected exhibits discussed in this paper

visitors were invited to drop a ball several times and to time and jot down the falling time to get an idea about uncertainty in measurements due to random effects.

The "*climate globe*" portrayed elements and physical processes governing the weather and climate, depicted by pictograms on a desk globe. The "*climate dart*" game exemplified the difference between climate and weather and why we may still face cold, wet or snowy conditions in a generally warmer future climate in Austria. The dartboards were colour coded to illustrate the frequency of different conditions under the present and future climate. By throwing darts at the boards, the visitors understood that in the future climate with more warming, the likelihood of hot summers are increased, but there are still chances of snow days, albeit at a lesser frequency.

The section concluded with a poster explaining the role of GHGs in ocean warming and subsequent sea level rise.

3.2 Anthropogenic Emissions and Responsibilities

This section explored factors causing climate change. The relationship between increases in anthropogenic CO_2 emissions leading to an accumulation of CO_2 in the atmosphere was explained through posters as well as sources and estimates of GHG emissions from various economic sectors. The "*CO_2 bubble chart*" depicted the relation between economic wealth and CO_2 emissions. The visitors were able to compare between different countries and reflect on how prosperity often leads to an increase in carbon footprint of a nation. A fact sheet to take home was provided. To exemplify the abstract measurement of emissions, a "*CO_2 video*" produced by CarbonVisuals (2012) visualised the hourly, daily and yearly amount of emissions in New York.

3.3 Individual Choices and Two Possible Futures

The "*choice game*" linked emissions with individual choices. It simulated individual responsibilities by allowing visitors to re-enact day-to-day choices in life, e.g., concerning mobility, use of electronic devices, choice of diet. The game was designed in such a way that if a majority of the choices were climate-friendly, the visitors were led to the "*blue room*" and if not, to the "*red room*". Both rooms illustrated possible climate futures visitors would experience relative to their choices (assuming that many or most of their contemporaries would act in similar ways).

The "*red room*" depicted temperatures in southeast Austria under model simulations (RCP 8.5), stating that in 2100 summer temperatures could be similar to present temperatures in Marrakesh, Morocco. The visitors were asked to respond to

questions such as "Where will I go for Holidays then?" or "Will skiing still be possible?". Their responses were collected on red post-its and attached to the wall, so that the room became redder in due course of the exhibition.

The "*blue room*" helped visitors visualise a world fuelled by low-carbon energy sources and a sustainable way of living. Posters depicted the still occurring, but attenuated, temperature increase as well as sustainable alternatives and innovations in the field of energy, construction, mobility, and agriculture. The coloured wooden 3D-"*energy cubes*" [based on a Greenpeace (2011) figure] illustrated the global available energy of various energy sources. It allowed the visitors to touch, feel, stack up and compare the total reserves of fossil energies with the yearly potential of renewable sources, which could meet or even surpass our current global energy demand.

3.4 Local Impacts of Climate Change

This section addressed the harmful impacts of climate change that can already be observed in Austria. A "*natural hazards*" poster depicted consequences of climate change in alpine regions, such as heavy and more frequent floods or retreating glaciers leading to debris flows or rock avalanches. The "*changes in our ecosystem*" exhibit, a poster cut into the shape of a mountain, exemplified alpine wildlife ecotypes and their expected changes due to climate change, e.g., migration of fauna or extinction of specialised species. A taxidermy mount of a black grouse and groundhog added to this exhibit.

3.5 Action on Climate Change and Debunking Myths

The last section of the exhibition issued a rallying call to the visitors to get involved in making a change to mitigate climate change. The climate change politics book described how the international community aims at mitigating climate change through international co-operation, ranging from the Rio Earth Summit (1992) to the Conference of Parties in Paris (2015). The "*climate activism tree*" pictured individuals and groups all over the world taking action towards climate change adaptation and mitigation. 19 initiatives were presented, spreading from individual contributions (e.g., avoid producing trash, eat vegan) to global campaigns to transform the fossil fuel economy. The exhibit also aimed at engaging visitors to reflect on their own efforts to minimise climate change and to motivate them to show engagement in climate activities, no matter on which level. Thus, the climate tree also invited visitors to come up with their own climate commitment, in posing with their face as a climate activist taking a selfie in front of the exhibition slogans and to share this photo online ("*I, climactivist*"). In addition, three short videos on climate activism were shown.

The "*stabilisation game*", a tossing game based on the concept of stabilisation wedges developed by Pacala (2004), helped visitors understand the potential of mitigation options to reduce emissions in various sectors. The visitors competed against each other to collect maximum emission reductions to win the game.

The last exhibit focussed on debunking popular climate myths. The aim was to expose and enable visitors on how to separate fact from fiction based on scientific findings. The role of humans, of the sun, agreement between research on global warming, consequences of small temperature increases and the reliability of climate models were addressed.

4 Drivers and Barriers to Successful Communication

Various factors supported or impeded the flow of scientific information. A review of these factors should assist researchers trying to effectively communicate scientific findings to the general public in a similar setting. The conclusions presented are drawn from individual experiences of the exhibition team members made during guided tours and interaction with visitors and from team discussions while assessing the impact of several exhibits. The observations discussed might not give a full picture of issues that may arise in communicating climate change in an exhibition, but reflect those, experienced and recognized by the team as the most influential or overlooked ones.

4.1 The Role of Guides

Communication theory highlights the significance of trusted messengers in the transmission of information (Goodwin and Dahlstrom 2014). The role of trusted messengers has been emphasised in climate change communication as well (Corner et al. 2015). Hence, even though the exhibits were designed to be self-explanatory, frequent guided tours were provided by the museum staff and the scientific project team.

The guided tours added a personal touch to the communication process and helped answer any immediate questions and concerns. Guides could adopt the story telling approach based on their individual research and newsworthy climate change-related events and thus help to reinforce the message. In doing so, they could not only provide information but engage the visitors in discussions to learn more about the topics related to the exhibits and maybe launch interest to get involved in climate change, even after leaving the exhibition. This role of guides, to encourage group participation and interaction, has also been highlighted as a key factor in engaging younger age groups in climate change conversations (de Vreede et al. 2014; Devine-Wright et al. 2004). Guides also tried to adapt their descriptions and explanations based on the age, interest, education level and other factors. For

example, with children the guides took care to use easy to understand language and avoid jargon. Geographical frames were also altered based on local and international audience.

All guides were part of the scientific project team or the museum staff. The scientists provided detailed information, briefed the museum staff before the start of the exhibition and assisted during the exhibition when questions arose. The close cooperation between museum staff and scientists as well as the possibility for guided tours enabling interaction with laypersons proved fruitful for scientists, as they could learn how visitors respond to their scientific message, whether they understood it correctly and how they interpreted its significance.

4.2 Addressing Uncertainty

Scientific uncertainty is common among all branches of science. A complex topic like climate change is also riddled with uncertainties. Understanding uncertainty is one thing, but communicating it is often difficult. The communication of uncertainty to laypersons is challenging, as there is always the risk that uncertainty is decoded as ignorance or the lack of knowledge. Not properly communicating uncertainty results in the propagation of mixed messages and general distrust of researchers by the public. Uncertainty was an important element in the design of exhibits. Two exhibits specifically tried to address uncertainty head on. The two presented plausible scenarios in the "*temperature wall*" illustrated a way to deal with uncertainty related to future developments, by showing the range of possible changes. The "*fall experiment*" addressed measurement uncertainty and showed the visitors how measurement and random errors contribute to uncertainty and how statistics can be used to obtain a best guess for plausible values.

4.3 How Much Science—How Much Simplicity?

When publishing and communicating research results in the scientific community, scientists ideally adhere to common standards in terms of objectivity, transparency and integrity. Compliance with such standards is supposed to guarantee a certain degree of reliability, validity and replicability of the results obtained. Adhering to such standards while presenting findings could limit the ability of the general public to understand the implications of the research. A purely scientific communication style might thus not be suitable when the general public is the recipient of the message a researcher wants to convey. As Weingart et al. (2000) illustrate based on an analysis of the debate over climate change in Germany, different actors handle this problem in different ways:

> … Scientists politicized the issue, politicians reduced the scientific complexities and uncertainties to CO_2 emissions reduction targets, and the media ignored the uncertainties and transformed them into a sequence of events leading to catastrophe and requiring immediate action. What we called the interference of discourses is characterized by the specific selectivities (both in the sense of inclusions and exclusions) occurring as the issue of climate change was communicated.

The design process of the exhibition was often confronted with such "selectivities". The trade-off was mostly between scientific correctness and completeness on the one hand and complexity reduction for improved comprehensibility on the other hand.

In the case of one exhibit, the "*CO_2 bubble chart*" (Section "Anthropogenic Emissions and Responsibilities"), a reductionist approach was used in the design by overcome comprehensibility issues. Specifically, the chart showed GDP per capita versus CO_2 emissions per capita. The absolute CO_2 emissions of a country was illustrated by the size of the bubble and the country map was added to depict how a world map would look like if the countries were ordered based on wealth and emissions. The anticipated take-home message was to understand the relationship between per capita and absolute national emissions and its possible significance in guiding international climate policies based on country level contributions to climate change emissions. However, interaction with the visitors during guided tours showed that while most visitors could grasp the relationship between per capita emissions and GDP, the inclusion of absolute emissions and country maps rather caused confusion, inter alia because many people were not familiar with the interpretation of bubble charts.

A positive example for reducing scientific complexity (without reducing correctness) and simultaneously increasing comprehensibility was represented by the "*climate dart*" (Section "The Basics of Climate Change"), informing visitors about the role of probabilities related to weather conditions in a future climate. Based on visitor feedback, it can be concluded that this exhibit facilitated the understanding of the role of probabilities in climate science and helped them to better understand the difference between weather and climate.

4.4 Importance of Local Frames

Climate change is a global phenomenon; however its potential impacts not only vary from region to region but also within regions. This regional variation could create a sense of psychological distancing to climate related impacts felt elsewhere. Communicating climate change through local frames, emphasizing its impacts on a local level and highlighting the potential of local and regional solutions could spread awareness and inspire action (Shome et al. 2009).

The exhibition had numerous positive examples of such local and regional frames. The impacts of climate change on the flora and fauna were depicted using

regional examples in the "*changes in our ecosystem*" wallchart (Section "Local Impacts of Climate Change"), climate induced "*natural hazards*" (Section "Local Impacts of Climate Change") illustrated recent rock fall events, and the "*temperature wall*" used climate model data for the Austrian region. Among the illustrations was also a *postcard*, which the visitors could take home that addressed an often very emotionally discussed topic about the future of skiing in Austria. All these exhibits using local frames were successful in increasing the visitor's sense of connection to the issue of climate change and its associated impacts.

Having said that, some exhibits were designed based on international data, which sometimes led to confusion among the visitors. One example was the "*choice game*" (Section "Individual Choices and Two Possible Futures"), where visitors made choices based on their everyday life to understand the consequences of individual actions on climate. Regarding the transportation sector, trains were labelled as an emission intensive choice along with aeroplanes and cars as compared to walking and bicycling. This often led to confusion among the visitors, since trains in Austria are overwhelmingly powered by electricity that is sourced from renewable energy. On a global level, however, many trains are still powered by fossil fuels resulting in a comparatively high carbon footprint. This geographical variation in making environmentally conscious choices needs to be carefully communicated to the public. In the example of the choice game, it was detrimental to inform Austrians that using rail transport is harmful to the environment. This underlines the importance of tailoring climate change communication to a regional context relative to the target group or to provide explicit information on what the facts were based on.

4.5 Getting Visitors Involved

Communication research has shown that simply "nudging" people in a top-down approach, e.g., by providing them with extensive information about climate change, is not necessarily effective in stimulating real-world action on the problem at hand. Instead, people should be rather engaged at an affective level by connecting to their emotions and feelings. Moreover, it is not recommended to only "make people afraid" of the consequences of climate change but to also show them examples of what they can do about it (Nerlich et al. 2010). We therefore deemed it important to illustrate positive examples of bottom-up approaches to climate change, such as grass root movements, which were presented in a section on climate activism (Section "Action on Climate Change and Debunking Myths").

Beside the climate activism exhibition part regarding what can be done to deal with climate change, visitors were encouraged to share their own climate commitment using the title "*I, Climactivist*". The initial idea was to have visitors take a selfie or have a photo taken by someone behind an empty photo frame or a board

featuring the exhibition's slogans that would have "I am a climate activist" written on it coupled with both German and English language hashtags (#KlimAcht, #CliMatters). Visitors would then be encouraged to share their climate commitment via social media sites.

In hindsight, this form of audience engagement and interaction did not work out very well as there is little evidence that visitors shared their climate commitments, which might be due to the following reasons: There was a large disconnect between the exhibit concept and the actual execution, due to time pressures and communication issues between conceptual and design teams. This resulted in limited visibility of the climate commitment part as it was covered by components of the climate activist exhibit, rather than being set apart spatially as a stand-alone exhibit. As no additional information was provided on the picture frame for which to take the photo with, the effectivity of the exhibit was further limited. Also, the exhibit was targeted at younger pupils, many of who do not engage with social media yet, so maybe other forms of engagement might have been more effective. In addition, visitors might have needed more time to reflect upon their climate commitments. Tour guides could promote such reflections by helping visitors to deal with the complex matter of climate change in terms of how they see themselves as being part of the problem or a solution to the problem. The failure of social media engagement in response to the exhibit does not necessarily mean that the display of climate activism was unsuccessful, but rather shows that small changes in execution of exhibits might have large impacts on how visitors engage with an exhibit.

4.6 Testing of Exhibits

Climate change communication is a multifaceted issue. Understanding this, the exhibition team dedicated time to discuss and challenge the proposed concepts and design ideas for exhibits right from the nascent stage. This interaction helped frame a common language with a consistent set of assumptions and allowed people to break out of their disciplinary silos and to question disciplinary blind-spots. This proved critical in the testing phase right from the generation of ideas to the design of the exhibit. Although, this multi-disciplinary examination helped in the better design of exhibits, time constraints did not allow for detailed on the ground testing of exhibits. The original idea was to invite members of the target audience to walk through the exhibition and provide detailed feedback on various aspects. This would have provided useful insights on how to describe certain exhibits during guided tours or the workability of certain exhibits among other factors. However, due to a limited budget and strict time constraints, it was impossible to incorporate insights from such a testing in redesigning the exhibits.

4.7 Languages

As a result of having an international team, it was decided to have a bilingual (German, English) exhibition. This posed challenges in mainly two ways. First, the team wanted to keep written information as short as possible but had to provide everything in both languages, thus doubling the text without adding more content. To ease an overwhelming text amount, the scientists made an effort to keep texts short and below a character limit, which was proposed by the art design team. Second, the exhibition used videos for two exhibits. Videos have strong didactic potential as they can provide good and easily understandable visualisation of concepts and in a screen-savvy society they capture visitor's attention easily. Ideally, videos would have been available in both languages. As the climate activism movies were originally in English and there was no budget for dubbing, the organisers decided to only use German subtitles. This proved successful for the "*CO_2 video*" (Section "Anthropogenic Emissions and Responsibilities"), featuring as good as not spoken lines and for one climate activism video (Section "Action on Climate Change and Debunking Myths") consisting of a sequence of short statements by children to very general climate-related questions. Due to the lack of story line, visitors could step in and out of the video any time. But English came out more problematic for two text-laden videos with a story line from start to end, which has been challenging particularly for some of the younger visitors. Therefore, multi-lingual exhibitions movies with strong visual and less audio content have potential upsides compared to movies that are very language-heavy. In addition, separated spaces would be preferable for (longer) videos with story lines, where they can be watched without interruption.

5 Conclusions

This study explored the possibilities of revamping a traditional form of communication, namely a museum exhibition, to relay climate change information and spur action against climate change. It identified the following main factors that affect climate change communication and which should be taken into consideration while communicating climate change in a museum setting:

- accounting for the regional context, i.e., experiences, local specifics, regulations in place, and particular cultural understandings play a crucial role and can support the formation of empathy with the topic and foster interest in getting involved;
- in many cases, a reduction of scientific complexity is required as well as recommended, but the selection of information needs careful consideration as to the basic message of the exhibit and a close cooperation between those responsible for content and design;

- a multi-disciplinary team is important to address complex topics such as climate change; the mutual exchange of varying perspectives within the team helps overcome disciplinary blinders and allows for the development of a shared language and a comprehensible narrative;
- scientists should be involved in briefing the museum staff and also interacting with visitors during guided tours; this involvement helps museum staff and visitors better understand the narrative of the museum along with the specifics of the individual exhibits; furthermore, it is crucial for researchers themselves to discern first hand, how their work is perceived by the public.

These insights can serve as guidelines for future endeavours aimed at communicating climate change through innovative channels of communication. Such undertakings, which draw on the scientific and human dimensions, are important for engaging young people in the climate change discourse and will help shape future policies aimed at mitigating climate change.

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Climate Change Communication in Higher Education Institutions: The Case of the North-West University in South Africa

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1 Introduction

Climate change is urgent and demands new ways of thinking and behaving. The challenge, however, lies in the fact that the idea of climate change is still amorphous for many audiences. It has been described as being "invisible, remote, abstract, global, complex, uncertain, and people see very little opportunity to affect it directly or meaningfully" (Moser 2010, p. 43). The challenge is compounded by the fact that interest in climate change as a phenomenon has in some countries actually declined in recent years, while scepticism has grown (Capstick et al. 2015).

On the African continent specifically, the impacts of climate change are very real for many communities, yet an 'information lacuna' on the matter continues to exist due to differences in the socio cultural, economic and structural contexts that prevail on the continent. Awareness remains too limited about the causes and impacts of climate change in this region (Chari 2016). The same may be said of specific African countries such as South Africa, where government's policy and programme attention is still chiefly focused on incidental issues such as improving service delivery and providing access to health care.

A strong case is to be made for improved communication on climate change. The use of an exclusively scientific framework, using mass media to transmit

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information, and the misidentification of target audiences etc., have created a feeling of distance and, therefore, lack of effective engagement (Moser and Dilling 2011). This stands in stark contrast to the international law and policy call for improved communication with the purpose of raising awareness and enhancing the understanding of climate change, as contemplated in the UNFCCC (art 6), the Paris Agreement (art 12) and Sustainable Development Goal (SDG) 13.3, for example. The implementation of art 6 of the UNFCCC further demands that a broad range of stakeholders, including scientists, teachers, the general public and youth, be involved. As per section 9—Observations of the Doha Work Programme on article 6 of the UNFCCC[1]—it is similarly necessary to involve the general public and each and every other role-player, including tertiary institutions. Universities, as centres of knowledge generation and dissemination in general, are instrumental in climate change communication efforts.

In the current context of limited understanding of climate change, universities, among other sectors of society, must help to communicate the matter. In addition to innovative teaching and research, they may be expected to promote initiatives and strategies towards a better understanding of the multidimensional nature and effects of climate change. By engaging people who are part of the problem but also those future decision-makers who can offer solutions, universities are ideally situated to increase climate change awareness and action.

Against this backdrop of the general discourse on climate change communication, this paper analyses a recent experience at the North-West University (NWU) in South Africa. Several activities were undertaken at the Potchefstroom Campus of the university in 2016 as part of the international initiative "Global Climate Change Week" and under the heading "Ready to Act?" The activities (involving different scholarly fields e.g. arts, natural science, education and law) for the first-time attracted a multidisciplinary group of students, academics and university staff who connected with one another and with the realities, challenges and opportunities of climate change.

The objective of this paper is to highlight the role of universities in fostering climate change communication and, in so doing, to contribute to the growing discourse on the need for improved climate communication. Based on the experience of the NWU, the paper identifies some of the challenges and opportunities of climate change communication initiatives and strategies in a specific tertiary institution. The research draws on the experience of one university only but still shows that universities offer a meaningful platform for broader and multidisciplinary academic communities to discuss the nature and effects of climate change, to think about the solutions and, ultimately, to motivate people towards taking action.

[1]See http://unfccc.int/cooperation_and_support/education_and_outreach/items/2529txt.php.

Following a brief review of the 'university and climate change communication nexus', the paper ventures into a discussion of the NWU experience during 2016 and concludes with some observations and recommendations for similar future initiatives.

2 Climate Change Communication in and by Universities

It has always been important to raise awareness of climate change and to foster public engagement in related matters. Still, more remains to be done in order to catalyse meaningful public involvement (Leal Filho 2009). As a matter of fact, "the understanding [of this problem] is superficial, personal concern is relatively low and ever-susceptible to be overwhelmed by more immediate, salient threats and interests" (Moser and Dilling 2011, p. 169). It is therefore essential to re-examine existing communication strategies and to develop alternatives in the quest for solutions to the challenges posed by climate change.

Because of their mandate to "serve society as agents of societal transformation" (Astin and Astin 2000, p. 34), universities are particularly well situated to increase climate change awareness and foster engagement on climate change issues. One of the ways to improve public engagement is to promote communication within and by universities as scholarly communities. In addition to innovative teaching and research, higher education institutions may typically be expected to promote campus-based initiatives and strategies towards a better and more holistic understanding of the multidimensional nature and effects of climate change. By doing so, they may (a) enhance the levels of awareness; and (b) engage academics, students and professional staff in action, irrespective of their scholarly fields and areas of expertise. Universities develop future leaders and decision-makers capable of understanding and responding to complex global climate change questions (Fahey 2012). Put differently, "[h]igher education students will need to make complex policy decisions about environmental issues [including climate change] from an informed perspective" (Keinone et al. 2016, p. 6).

However, to date, higher education institutions "have had a lethargic response to urgent needs to mitigate the [climate change] problem" (Lemons 2011, p. 379). In many parts of the world, university students (despite being part of the so-called "climate change generation" who grew up with more scientific certainty and information about climate change) still hold misconceptions about the basic causes and impacts (e.g. Wachholz et al. 2014; Keinone et al. 2016). When looking at the levels of emphasis being placed on climate change at universities worldwide, it appears that while teaching and research receive some attention, there seems to be a "low degree of emphasis on climate change in *campus activities*" (Leal 2010, p. 14).

Despite its being considered a scientific issue, "climate change is not a matter of concern exclusive to scientists" (Leal Filho 2009, p. 12). As Leal (2010) states "for various reasons, climate change as a topic deserves proper attention and needs to be taken more seriously by universities. It can no longer be regarded as a domain of

meteorologist or physicists as has largely been the case in the past. Instead, its deep… economic and social roots mean that climate change needs to find its way across all relevant parts of university programmes" (p. 18). Universities reach a wide audience and are good places to develop climate change communication initiatives in order to speed up the idea that there is an urgent need (a) for action, and that (b) local and personal actions can make a difference (Moser 2010) while (c) universities can readily promote the idea that it is important to address the problem in a holistic way and that solutions need to be found from many different disciplinary angles. However, universities must walk the talk as well.

Broader, more participatory and multidisciplinary collaboration across faculties within universities offers an opportunity for natural scientists (traditionally involved in this task) to present technical and scientific information on climate change (Moser and Dilling 2011) but also to reach other audiences. Students and academics from various disciplines and programmes (e.g. education, law, human health, business, economics, religion, sociology and art) can also together frame climate change from social, scientific and economic angles in order to close some disciplinary-related knowledge gaps (Wibeck 2014; Leal Filho 2009).

A more rounded understanding of climate change may have fruitful spin-offs among students and civil society members alike. It has been reported that "people are more likely to take action when they feel a sense of affiliation with the individual or institution making the request" (CRED 2009, p. 43). As climate change can be a "tough issue to engage with" (Moser 2010, p. 33), universities can promote climate change communication by a combination of top-down and bottom-up initiatives and strategies tailored for local contexts (Ockwell et al. 2009). While the nature of such initiatives and strategies will depend on the characteristics, challenges and context of each institution, the localisation of climate change could be more effective and may "motivate people to engage in information regarding effective local responses to climate change" (Norton et al. 2011, p. 306).

Climate change communication is not just about conveying information via traditional one-way channels (like newspapers or radio programmes). Due to the privileged position of universities as places of knowledge transmission and the birthplace of dialogue, two-way communication modes have significant potential. In fact, interpersonal discussions and deliberations (including panel discussions, talks, movie screenings followed by debates etc.) appear to be more persuasive and more conducive for engaging people in the pursuit of behavioural change (Moser and Dilling 2011). The outputs of artistic disciplines such as the visual or performance arts, for example, may help to bring to life the complexity and relevance of the problem, its multiple impacts, and possible responses to it. By making the causes and impacts of climate change visible, the use of art forms can boost the cognitive, affective and behavioural aspects of climate change communication (Wibeck 2014). Yet, the challenge is to "address all three aspects of climate change communication…without enhancing a sense of fatalism and disengagement" (Manzo 2010, p. 207).

Because "belief in and concern about climate change are not automatically preconditions to action" (Wachholz et al. 2014, p. 134), effective communication of climate change in higher education institutions should ultimately culminate in

action. Very pragmatically, universities could promote and facilitate climate-friendly practices and projects within the university like car sharing, energy saving contests or recycling campaigns, for example. These initiatives demand the continued support of students, academics and university management. It also follows that the experiences of and lessons learned in different universities across the world must be shared. The dissemination of learning experiences on universities' communication of and actions taken in response to climate change is as much part of the overall solution as the projects and practices themselves.

3 Improved Climate Change Communication in a South African University: The GCCW/NWU Experience

3.1 Background: The Global Climate Change Week (GCCW) Initiative

The GCCW is a recent global initiative that started in 2015 under the direction of academics and students from the University of Wollongong in Australia.[2] It offers a platform to academic communities (academics, students and staff at universities) from different disciplines to "speak up" and share ideas in order to engage more communities on the topic of climate change (Wake 2015). During the GCCW (which takes place annually during the second week of October), academic communities are encouraged to develop voluntary activities on university campuses in order to raise awareness, inspire behavioural change, and positively contribute to climate change policy. Such activities are recorded on a global map highlighting the responses and diversity of the academic communities that participate each year.

During the first round, held in October 2015, 301 academics from 51 countries participated in this international initiative. Working across disciplines, academics and students from five continents organised several activities reaching different audiences but all seeking to achieve a common goal (Wake 2015). For the second round in 2016, an estimated 288 activities from different parts of the world were registered to be undertaken during the GCCW. Notably, in 2016 academic communities from the African continent took the lead by registering a significant number of activities, highlighting the continent's interest in reaching more people in one of the regions hardest hit by climate change. It was also the first time that South African academics participated.[3] South Africa's North-West University for example organised a number of activities to raise awareness of climate change and to foster engagement on the topic on campus. The next section elaborates on these activities.

[2]See the initiative website page, accessed 26 November 2016 http://globalclimatechangeweek.com.

[3]See the 2016 GCCW map, accessed 26 November 2016 http://globalclimatechangeweek.com/gccw-2016-map/.

3.2 The Process: The GCCW at the North-West University (GCCW/NWU)

The GCCW/NWU was held from 10 to 18 October 2016 at the Potchefstroom Campus of the North-West University, South Africa. Organised by the Faculty of Law and supported by the NWU Sustainability and Community Impact Office, as well as by the faculties of Education and Engineering, the GCCW/NWU was a first of its kind project on climate change communication carried out by this South African university.

Under the heading "Ready to Act?", the GCCC/NWU aimed at (i) disseminating and facilitating access to information and increasing knowledge; (ii) promoting a deep and comprehensive understanding of climate change; (iii) raising campus-wide awareness of the problem and the need for commitment to climate action; and (iv) fostering scholarly discussion among the campus community on the challenges of climate change and opportunities to address them. This initiative sought to achieve these objectives by means of simplistic, interdisciplinary, critical and entertaining activities, whilst building networks among students and academics alike.

The GCCW/NWU activities focused on the causes, complexities, risks and impacts of climate change (globally and locally) from the perspective of various scientific fields represented on campus, and highlighted practical responses to help in addressing the challenge. The activities focussed on themes related to, for example, the anthropogenic origins of climate change, its impacts on human health, biodiversity, water, energy, oceans and food, as well as the applicable international and South African legal frameworks. While some of the activities spanned the entire week, others were scheduled for a specific day of the week. The marketing of the events took place via social networks (a Facebook page was created by the organisers)[4] and printed posters on campus.

The GCCW/NWU activities described in Table 1 included both one-way and dialogic two-way forms of communication, as briefly described below.

3.2.1 One-Way Communication Activities

Some of the events organised were simply aimed at spreading the word and distributing information on climate change without necessarily entering into detailed discussions.

A book display was organised in the main passage area of the campus' principal library (Fig. 1). Aimed at disseminating information and increasing knowledge, the books on display included publications linking climate change with different fields (including law, geography, ecology, natural science etc.) as well as Master and PhD theses of NWU students on this topic.

[4]See GCCW/NWU Facebook Page www.facebook.com/climatechangenwu/.

Table 1 GCCW activities organised at the GCCW/NWU in 2016

Activity	Opportunities	Challenges
Book display	Easy to organise; providing information; reaching wide range of university members; possibility to focus on academic papers/books/theses written by faculty and students	Encouraging academic community members to take advantage of the display
Launching event with promotional items	Attracting students and academics while helping to display the programme activities; helping to establish a face-to-face dialogue in order to know community's concerns; raising awareness; engaging participants in the communication initiative	Selecting an open, high visibility space; carrying economic and environmental cost of items production; bypassing consumerism attitudes and motivating participants to join additional events
Recycling and poster art exhibitions	Addressing climate change issues from non-science fields; reaching a wide range of people including climate change untrained; emotional impacts; if the authors are students it will be easy to reach other students; several themes can be addressed; if interdisciplinary, students learn about participatory research by engaging with different fields; possible long-term display	Willingness to organise and participate in a long-term project; closing the knowledge gap of artists; coordinating work when involving many participants; time-consuming; adequate venue could be required; could be expensive
Movie screening followed by a debate	Variety of commercial/free options; simplifying organisational efforts while providing a full picture of climate change issues and solutions; reaching a wide and diverse audiences; fostering debates and networking	Could be expensive if licence fees requested; adequate venue needed; time management for post-movie debate
Panel discussion	Multidisciplinary event; traditional academic activity; climate change knowledge available on campus; participation of university members as speakers; credible and trusted messengers; increasing networking for future initiatives	Time management; selecting inspiring speakers; selecting appropriate themes within numerous climate issues and fields involved; when many speakers give presentations, the discussion time could be shortened
Short talks on climate-friendly university projects and initiatives	Linking scientific information and practical solutions; disseminating information about university's green projects and initiatives; offering opportunities to take individual or collective climate change actions	Selecting inspiring speakers; effective engagement of participants in the projects or initiatives; sustain project and initiatives to generate a real behavioural change

Fig. 1 Climate change books display. *Source* The authors

The display was backed by the library's TV screening of a PowerPoint presentation showing extracts of related scientific journal publications written by NWU members. In this way, relevant and recent information was shared with students and staff at no cost, with little time having been needed for the preparation of the material and the related logistics.

A recycling art exhibition was also organised with the support of the Campus Art Gallery. The activity showcased local artists' works made out of old tyres, wool or animal bones, among other recycled waste materials. The exhibition offered information to students and interested community members on what can be done through the reuse and recycling of waste materials to minimise the environmental footprint of modern lifestyles.

In order to deliver in print the message that there is an urgent problem and that the NWU campus community needs to take action on climate change, the GCCW/NWU initiative also received media coverage in a press article published in the campus student newspaper, the "Wapad".

In addition, digital channels were used to help spread the GCCW message among the campus community. With the support and assistance of the marketing office of the NWU, two videos featuring the main organisers were recorded and uploaded on the University's website.[5] Together with the press article, the videos introduced and explained the initiative, stressed its importance, and served as a public invitation to join the movement, while underscoring the need to talk about climate change in the university environment. These strategies served to communicate information on the GCCW/NWU activities and on climate change in general with a broad range of academics and undergraduate and post-graduate students.

[5]The videos are available at https://www.facebook.com/pg/NWUPuk/videos/?ref=page_internal.

3.2.2 Two-Way Dialogic Communication Activities

In addition to the one-way communication activities described above, the GCCW/NWU included opportunities for face-to-face communication and dialogue in smaller groups.

The GCCW/NWU started with a launch event to introduce the programme for the week, as well as to present in an introductory fashion matters on climate change as perceived by the academic environment. The launch included the distribution of promotional items (T-shirts and caps) to market the initiative and the week's programme. The launch event took place in a strategic crossing area on campus, which gave to the organisers an opportunity to interact with people on campus in an informal conversational manner. The launch also offered an opportunity for the campus community to canvas some of their values, motivations and commitments towards climate change on a large "green" banner.

A second art exhibition was organised, albeit in a different way. The artists were students of the Faculty of Education (the Creative Art class) involved in an existing annual programme of interdisciplinary engagement with academics and students of the Faculty of Law. For the third year now, the education students interacted with their peers in the field of law in order to develop original educational art posters sharing information related to people's rights.

While students and academics from the Faculty of Law provided guidance from the perspective of the law, the education students, under the supervision of their Creative Art lecturer, developed educational posters as a potential teaching tool at schools. The 2016 edition of the programme was included in the GCCW/NWU with a focus on "The right to a healthy environment in a Climate Change era". As such a right is enshrined in section 24 of the Constitution of the Republic of South Africa, 1996, the environmental law students and academics helped with the necessary legal framework as well as with information related to climate change issues. On this basis, the education students identified the problem, brainstormed together, discussed and received some further inputs from members of the Law Faculty, designed their posters and finally illustrated the problem and solutions in images presented in poster format. The education students received additional support from a NWU design software expert. In the end, the outputs of this joint effort took the form of a poster art exhibition during the week of the GCCW. The posters focused on different aspects of climate change (including water and food security, renewable energy, fracking, biodiversity loss, waste and air pollution), made it accessible to different audiences, and generated emotional connections with the topic (Fig. 2). The opening of the exhibition gathered together members of both faculties and other interested people, who engaged in informal discussions triggered by the messages conveyed through the posters. Notably, very important messages on climate change were conveyed by young, undergraduate students in a field other than natural science.

As climate change films are known to "promote environmental responsible attitudes and social change" (Ramirez 2012, p. 257), a free movie screening was organised. The movie featured some of the real-life impacts and consequences of climate change but also flagged opportunities for and the positive impact that

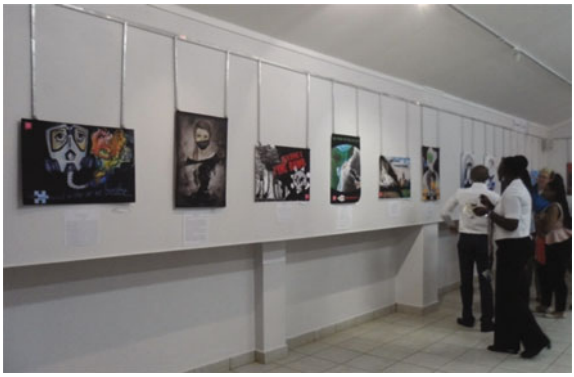

Fig. 2 Climate change posters art exhibition. *Source* The authors

Fig. 3 Panel discussion. *Source* The authors

community action may have. The movie emphasised the fact that opportunities exist whereby people can meaningfully react to climate change. The movie was to be followed by a critical discussion of the film's messages.

One of the highlights of the week was a formal panel discussion involving experts from the NWU and elsewhere, and representing different scholarly fields such as law, natural science, zoology, atmospheric science and environmental management.

The presentations by the panellists focused on statistics and data reflecting the urgency of climate change, the need for a holistic understanding of it, its causes and global and local impacts, as well as some new understandings of possible solutions. The specific themes that were addressed included the links between climate change and oceans, health and air quality and recent international assessments and trends (Fig. 3).

The GCCW/NWU eventually concluded with an open-air amphitheatre series of short talks on climate change itself and activities and endeavours on campus and by NWU members towards making a positive change. One of the talks introduced a solar greenhouse project developed by the Engineering Faculty and a solar company aiming at providing food, electricity and jobs to townships while promoting

the consumption of local products and the reduction of food transportation from other parts of the country (Midweek 2016). In addition, the activity included an exhibition of electrical cars as an important alternative to internal combustion cars, to reduce GHG emissions. The solar car built by the Engineering Faculty is an important initiative to contribute to the momentum of electric mobility. It even took part in international competitions (Van Zyl 2016). Similarly, a car retrofitted towards a local electric engine was put on display.[6] The message was clear: the scholarly community and others must start to think out of the box, and some members of that community have already started to do so.

3.2.3 Results: The Response of the NWU Academic Community

The GCCW/NWU triggered academic discussion on the climate change challenge. The initiative brought together established academics and undergraduate and post-graduate students from different scientific fields including law, education, the natural sciences (atmospheric science, biology, zoology etc.), engineering, health and nutrition, disaster management, anthropology, and theology. The GCCW/NWU reached an estimated audience of 200 participants. The dedicated Facebook page received more than 300 visits while the videos published on the NWU Facebook attracted more than 3900 views. The interest was significant.

The initiative enhanced the university's visibility by being part of an international campaign to raise awareness on climate change. It also offered the opportunity to showcase the university's existing climate change activities.

Based on the interaction and feedback received from the participants as well as the results of two surveys conducted among students of the Faculty of Education and attendees of the panel discussion, the GCCW/NWU was received as a timely and necessary initiative. Feedback further indicated that the university community was pleased to witness the emergence of the initiative as there is agreement that more must be done to raise awareness about climate change. By touching on different fields, the GCCW/NWU displayed information on a variety of themes, raised awareness and opened some debate on the matter of climate change. Some participants expressed surprise when they realised that the Faculty of Law had initiated the project. This suggested that the issue of climate change is still thought to be the almost exclusive concern of natural scientists. According to the participants, the ability of academic experts to communicate their findings and research on the complexities of climate change is very important. The activities on the programme, which involved participants from different backgrounds, certainly enabled cross-discipline interaction and communication, and established some new (informal) networks. As one may expect, funding and institutional support from the university was fundamental to realising almost all of the activities.

[6]Accessed 26 November 2016, https://www.zingclub.co.za/.

A lot may be learned from the 2016 experience for the future organisation of projects of this kind—at the NWU and elsewhere. Some of the limitations and shortcomings that transpired as part of this research include the following: the use of posters and social media for the marketing of the GCCW resulted in limited exposure, since the week followed directly on a university recess period; the limitations of the marketing strategy used resulted therein that a small audience was reached; due to the limited marketing and the novelty of the initiative, the university management and key decision-makers were not fully on board, hampering the mobilisation of all the faculties; the week was organised by a very dedicated but too small team of people and it really ate into their own academic and personal schedules; the 2016 programme leaned towards an excessive focus on matters of climate mitigation while adaptation is actually of greater concern in Africa and in South Africa; the managing of time during the events was sometimes a concern to properly ensure feedback opportunities and to facilitate questions and observations from the audience as well as optimal two-way communication on matters that academic presenters and mixed audiences regard to be of interest and/or great importance; and too little attention was paid to ensuring that the GCCW/NWU was environmentally friendly in itself (e.g. green procurement practices could have been adopted). As the NWU comprises more than one campus, it was a real challenge to involve all campuses—using media and information technology options should have been tried.

4 Conclusions and the Way Forward

At best one may label climate change as a wicked problem with too many challenges to start to disentangle. While uncertainty abounds about various aspects of the effort to respond to climate change, we know for certain that many actors from many different fields need to work together, and that information and knowledge are key. This paper has reflected on how universities should be seen as part and parcel of the climate communication effort—globally, of course, but also in a developing country such as South Africa. The paper has also shown how the modest beginnings of the North-West University towards presenting a dedicated consolidated climate communication project in 2016 offer various useful insights into the opportunities and challenges that universities may expect to encounter. The experience at the NWU has also revealed that in some instances a single unifying programme may be needed to bring together the excellent work already taking place in different administrative offices and academic faculties in a single tertiary institution. The real challenge of climate change communication in and by universities lies in scholars realising that there are alternative dissemination opportunities to be embraced, and in university administrations realising how small operational changes may have great positive impact on the reduction of the university's carbon footprint.

On the basis of the recent experience of the NWU project (the GCCW), the following recommendations are made:

- Climate communication initiatives in universities and also in future at the NWU itself must:
  - Be planned well in advance and must be part of teaching and budget cycles;
  - Bring together established scholars and students from different backgrounds (faculties) to enable a deep and integrated understanding of complex climate change problems;
  - Be focused on both climate mitigation and adaptation;
  - Be marketed in creative and diverse ways suitable for the local context;
  - Be a welcoming and inviting project for researchers and scholars in all disciplines represented by the faculties on the university campus—this requires a sensitivity for jargon, for example; and
  - Be 'bottom-up' while simultaneously being 'directed' and 'supported' by senior management, which has the leverage to make available human and financial resources.
- Given tight university budgets, additional funding from the private sector or government structures (e.g. the local municipality) may have to be sourced.
- Every effort should be made to involve the university community as well as members of the community in which the university is situated, including schools, businesses, the local government authorities and residents of informal settlements.
- Climate change communication initiatives must produce a zero footprint approach—in its procurement processes, for example.
- Climate change communication must be a continuous and sustainable exercise. Once-off events or programmes such as the GCCW/NWU should serve as hubs for new ideas and as opportunities to showcase existing good work in and around the university.
- The actual programme for an initiative such as an annual GCCW on campus must be extremely carefully planned to ensure maximum exposure, to ensure generous time for discussion and interaction, and to attract the attention of the campus community and members of the community in which the university is located.

We are of the view that a single case study such as the one of the NWU offers limited results to firmly conclude on the role of universities in climate change communication. It offers a good understanding of the options and opportunities in a developing country context, but more research may have to be conducted in and by universities in the Global North and South. The key learning point perhaps has been that scholars and universities should in future continue the incredibly important work on climate change as a phenomenon itself but should not turn a blind eye on the importance of communicating more broadly on the topic to a variety of experts and other audiences.

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Traditional Ecological Knowledge as a Contribution to Climate Change Mitigation and Adaptation: The Case of the Portuguese Coastal Populations

Joana Gaspar de Freitas, Maria Rosário Bastos and João Alveirinho Dias

1 Introduction

One of the consequences of global climate change is mean sea level rise. According to projections, the thermal expansion of the oceans and the melting of mountain glacier and polar ice caps will be responsible, until 2100, for a rise between 0.26–0.55 m and 0.45–0.82 m (IPCC 2014). This will have serious impacts on coastal zones already deeply affected by human activities. Fluvial and maritime engineering works, agriculture, afforestation and urbanization have been contributing to the reduction of sediment's availability and the destruction of the natural defenses of coastal systems leaving them more vulnerable to extreme weather events (Nicholls et al. 2007; Neumann et al. 2015). The combination of accelerating mean sea level rise and

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degraded coastal systems can have catastrophic consequences for the billions of people living in low-lying areas near the ocean, namely in some of the biggest cities of the world. Agriculture, industrial and urban land loss, through erosion or submersion, surficial aquifer and soil salinization and changes in ecosystems put at risk ecological, economic, social and cultural values and activities. These impacts, however, are scale-dependent affecting countries, regions and communities in different ways, in result of local conditions (Clark et al. 1998; Dolan and Walker 2004).

General knowledge about climate change and sea level rise point to a worldwide tendency, but it does not help to understand local consequences. Several authors have stressed that future changes are global, but they must be addressed locally (e.g. McNeill 2008; Endfield 2014). Adaptation and mitigation policies to be effective must account for the "multiples ways of knowing environments, of living in places and of imagining the future which are embedded in local cultural practices and knowledge-making traditions" (Hulme 2010). Otherwise, they will be de-contextualized, top-down approaches of worldwide knowledge detached from meaning-making. Places and resources have cultural and symbolic values for people that cannot be apprehended by economic models or global perspectives (Hulme 2010). The last IPCC report (2014) recognized the relevancy of this view considering that indigenous, local and traditional knowledge systems and practices are a major resource for adapting to climate change. However, the same document admitted that this knowledge has not been "used consistently" in mitigation and adaptation efforts.

Many authors (e.g. Berkes et al. 2000; Usher 2000; Nelson 2005; Houde 2007; Berkes 2008; Delicado et al. 2012) have been tackling the connection between local knowledge and environmental issues, stressing the need to include traditional knowledge-holders in environmental assessment and management to increase socio-ecological systems resilience. Most studies about these matters have a short chronological spectrum referring mainly to present indigenous communities (e.g. Berkes et al. 2007). The researchers involved are normally ecologists and anthropologists interested in conservation biology and resource sustainability (e.g. Berkes et al. 2000; Drew 2005; Berkes 2008). But there are other perspectives, Carey and Garone (2014) point that climate histories on folk knowledge can offer key insights into past climatic conditions and historical societal responses. However, there is a lack of studies on these issues. This work aims to fill a part of that gap. The information used, primary and secondary historical sources, was collected in archives and libraries, it comprises a selection of newspapers, oral traditions collections and field trips observations (Peixoto 1899; Oliveira and Galhano 1964; Vasconcelos 1975), and it is based in previous works (Freitas 2009, 2016a, b; Bastos et al. 2015; Freitas and Dias 2015). Historical research is fundamental for recovering the ways of life and the know-how of communities that are almost gone, preserving a knowledge that is important to present and future resilience.

In this chapter "local knowledge" or "traditional ecological knowledge" (TEK) stands for "all types of knowledge about the environment derived from the experience and traditions of a particular group of people" (Usher 2000). It can also be called "empirical knowledge". TEK includes statements of fact about the weather, resources, coastal waters, currents, seabed, animal behavior and coastline changes

based in long-term observations (Usher 2000). It also refers to ensuring survival by developing appropriate and effective strategies, tested by trial-and-error and feedback learning, using the available resources and the existing technologies (Berkes et al. 2000). This type of knowledge is associated with localness, it has ancient roots and it is transmitted from one generation to another (Houde 2007) through oral history and cultural practices. "TEK can be viewed as a "library of information" on how to cope with dynamic change in complex systems" (Berkes et al. 2000).

In the Portuguese coast, in a low sandy-area running from Espinho to Nazaré, the fishing communities developed strategies to cope with a very dynamic and variable environment. Without modern technologies and using only the available resources, these groups established special forms of architecture, seasonal activities, different subsistence sources and local empirical knowledge (about the weather, the coast and the biodiversity) that help them to survive in the littoral rough conditions. These key-strategies are believed to be especially useful to inform present coastal management in face of climate change. Twentieth century's transformations to this littoral, including the arrival of new populations and the growth of urban areas, contributed to the disappearance of traditional knowledge and the loss of the perception of the risk of living in such a dynamic place, increasing the exposure and vulnerability of people and infrastructures to sea and weather hazards.

This text is about fishers' communities, but not from the fishing resources and fishing activities point of view. The purpose here is to discuss sustainable coastal management. So, the objectives of this chapter are (1) to identify some aspects of the TEK of the Portuguese fishers; (2) compare it with mitigation and adaptation measures being proposed nowadays to set which ones are more suited to the specificities the coast based on long-term proven effective solutions; and (3) to show how this knowledge can be useful in communicating with decision-makers and coastal communities making them more aware of future changes and the need of building a more sustainable development.

2 The Portuguese Coastline: Situation

Since mean sea level stabilized in the Portuguese coast about 3500 years ago, the main factor of change in this coastline is the sediment budget. When there is a big supply of sand to the coast there is accretion, when sand is missing there is erosion. Until the twentieth century, the tendency was the silting-up of estuaries, lagoons and gulfs and strong sand supply to the coast. Human activities, like agriculture and deforestation, contributed to this positive sand budget. The low-sandy coast between Espinho and Nazaré, for instance, was covered with dunes, in some parts, with kilometers wide. Until the end of the nineteenth century anthropic impacts in this seashore were still quite reduced and the coasts were mainly modeled by climatic and oceanographic phenomena (Dias 2005).

The last two centuries were a turning point for the littoral. The (re)discovery of the therapeutic use of sea water in the end of the eighteenth century transformed the

coasts of Europe into the recreational playground of the elites. In the nineteenth century, seaside resorts and railways popped up along the shores and later, in the twentieth, the automobile and the airplane helped converting it into the favorite vacation destination of the masses (Dias 2005; Freitas 2007). The scale of the changes in this century was huge. In Portugal, after the 1960s, rural population massively left the country's interior and settled in the littoral, especially around the cities of Lisbon and Oporto. In the last three decades, rural depopulation, tourism and the construction industry were responsible for the intense urbanization (and suburbanization) of the coast (Schmidt et al. 2012). Meanwhile the construction of hydropower dams in the main rivers, the taming of riverine environments, the expansion of ports' jetties, the dredging of estuaries and the building of groins and seawalls caused profound changes in the sedimentary budget of the littoral, inducing coastal retreat and producing serious erosion problems (Dias 2005; Freitas 2007).

In the Portuguese coast, mean sea level rose about 15 cm during the twentieth century, corresponding to an annual average of 1.5 mm. A rate that has been increasing faster in the last decades (Dias and Taborda 1992; Antunes and Taborda 2009; Schmidt et al. 2012). Studies show that coastal erosion is probable to grow 12–15% until 2100, due to changes in the rotation of waves orientation, causing an increase in sediment transport along the coast, affecting especially low-lying sandy areas (Santos and Miranda 2006; Andrade et al. 2007). There is also the possibility of a rise in frequency and intensity of the storms affecting the western coast of Europe (Santos et al. 2014). The expected scenarios for the littoral of Portugal point to the growth of risks upon coastal urban areas. In the last decades, however, authorities and real estate promoters acted as if the coast was stable, allowing to and building in risk areas, so that people could have a "house with a sea view". Now, because of climate change and degraded coastal systems, those who live near the shore are more vulnerable to natural hazards and decisions must be made concerning the future.

3 Historical Settlement: An Overview

Some areas of the Portuguese coast have been inhabited since ancient times, its resources (fish, salt, seaweeds, driftwood) being a factor of attraction for human populations. For long, settlement was concentrated in sheltered coasts, like estuaries, coastal lagoons and deep bays. Cities with old maritime traditions (e.g. Lisbon, Oporto, Aveiro, Tavira) grew in protected areas, flourishing because their privileged situation (close to the sea, but far from its dangers) and activities (sea trade, fishing and salt production). People, however, rarely lived on the open coasts. Environmental conditions—exposure to extreme weather, large dunes, non-existence of fertile soils, fresh water scarcity—and human factors—piracy, low technology, absence of roads and a general demographic deficit—imposed restrictions to settling. Straight exposed coasts remained deserted, or inhabited only by small communities of fishers, until the

mid-nineteenth century. This phenomenon was not exclusively Portuguese, being characteristic of the settlement in the European Atlantic coasts (Cabantous 1990; Freitas 2016a). Early mariners navigated from harbor to harbor, estuary to estuary, avoiding *terra nullis* (Gillis 2012), those empty places in the littoral that Corbin (1988) called the *territoire du vide*.

The coast between Espinho and Nazaré is a straight low-lying sandy area. This seashore is one of the most energetic in the world. High energy dominant NW waves act in this open coastline creating a violent surf that hinders the passage of boats and renders fishing dangerous and almost impossible for part of the year. Especially between October and March, when storms are more frequent (Moreira 1987, Dias et al. 1994). For long this coast imposed serious limitations to human survival. Settling here was a slow seasonal process, carried by small marginal groups, coming from inland to explore the fishing resources during the summer, when the weather and the sea allow it.

Indigenous (and past) communities developed unique lifestyles deeply adapted to local climate, geography, vegetation and wildlife by elaborating coping mechanisms to deal with their environments and current extreme events (UNEP 2002). People living in hazard-prone areas develop a set of practices of risk minimization and adaptive strategies integrated in their daily lives so as not to be taken by surprise (Pfister 2011). Bankoff (2009), for instance, found in the Philippines a "coherent body of local knowledge" that helps communities to reduce the impact of hazards and avoid the occurrences of disasters. Traditional agricultural practices and typical architecture are impact minimizing procedures, seeking to limit losses and facilitate recovery. Frequent migration and relocation are preventative coping measures to avoid exposure to hazards. The author (Bankoff 2009) also mentions the sense of community, the degree of interdependence and the strong social support networks as important factors in dealing with environmental uncertainty. In the Portuguese coast, similar examples can be found. For instance, fishers' associations (*confrarias*) and associative fishing companies protected the orphans and the widows. Other examples are connected to architectural forms and building materials, land use, resources exploitation and knowledge about the weather and the biological cycle of species.

Living by the sea only during the fishing months, fishers built precarious shelters, called *palheiros*, from raw materials available in the area, usually wood and beachgrass (Fig. 1). For centuries, the *palheiros* were the only kind of house on the seaside (Bastos et al. 2015). Seemingly fragile, consisting of wooden structures and thatched roofs, these buildings resisted storms, strong winds and salt water sprays. The wood used (pine) was treated with *sil* (sardine oil) to persist through time. The floor was covered with reed, a good insulator, retaining the soil's humidity and the heat (Chaves 2008). Depending on the specific features of the coast, the *palheiros* were built directly on the dunes or on piles buried in the sand. In expanses of large dunes, the piles—that could reach the height of a man or higher—were essential to allow sand and water to flow and to prevent the buildings from quickly being buried or flooded. Usually erected on top of the dune, which followed the edge of the beach, these stilt houses could be lifted from their primitive level or moved inland, to escape the tides

Fig. 1 *Palheiros* from Costa de Lavos (Figueira da Foz). Photo from the Photographic Archive of the Municipality of Figueira da Foz

and the movement of sand in the area closer to the sea (Peixoto 1899). For this purpose, the building was raised with levers, placed on logs and pulled by oxen to the appointed location, where it was then reassembled (Oliveira and Galhano 1964). Another major advantage of this type of construction was its own perishable condition, it was not expected to have the longevity of a house made of stone and lime. When hazards such as sea flooding or fires destroyed part of these settlements, they were easily rebuilt. Given the geographical constraints and the available resources, fishers developed an architecture perfectly suited to sandy soils and to a coastline continuously on the move (Peixoto 1899; Vasconcelos 1975). For Cadima (2004) "the traditional and vernacular architectural examples are rich in bioclimatic and sustainable solutions, eco-conscious, and reflecting adjustments to local conditions. The rediscovery of these examples has often served as a model of sustainability".

The settlement of communities in a hostile coastline entailed great adaptability to the environment and the development of survival strategies (Souto 2007). Strategies that included knowledge about coastline changes, working cycles set by nature's rhythms and the diversification of activities. For a long time, maritime jobs were precarious, seasonal and based on occupational pluralism. At the end of the fishing period, generally in October/November, populations looked for alternative income sources. Many returned to their home towns inland or sought protected areas—in lagoons, rivers and estuaries—where they could fish during winter. Others became rural laborers during that season (Amorim 2001): fishing was then just a complement to agriculture. Many proverbs from the Portuguese oral tradition provide examples of popular wisdom regarding seasonal activities, weather conditions and the biological cycle of animals and plants (Freitas 2016b).

"The specialized fishing village did not emerge until the eighteenth century, when farming and fishing finally began to differentiate" (Gillis 2012). In Espinho-Nazaré coast, permanent settling by fishing groups occurred in late eighteenth/mid nineteenth centuries. Population growth, urbanization and industrialization created a bigger demand for fish among city dwellers. Sardine can industry, improvements in catching's technology and better distribution networks contributed to the proliferation of these villages. In the same period, the Portuguese elites discovered the therapeutic use of sea bathing and seasonally moved to the shores. First, they rented the fishers' *palheiros* for the summer; later, houses, hotels, restaurants, casinos, promenades were built. It was the beginning of seaside resorts, connected to new perceptions and uses of the coasts. The first to build permanent houses on the beach, placing them as close to the sea as possible, were upper and middle-class inlanders totally unware of coastline variability and rough weather conditions (Gillis 2012). In the littoral between Espinho and Nazaré the first erosion problems—strongly damaging some villages—started precisely after the settlement of the new comers (Freitas 2009). During the twentieth century, fishing populations were increasingly confined to some harbors, pushed off the beaches by summer vacationers. Land property rights, rising property values and zoning laws (Gillis 2012) ended their mobility and ways of life. The artisanal fishing communities of Espinho-Nazaré coast are now drastically reduced: fishing low incomes and difficulties imposed to the activity (coastal erosion and competition for the use of the beach) resulted in a significant decrease in the number of fishers (Souto 2007). The old fishing places were converted into touristic seaside villages, second home areas and dormitory suburbs. With the breakdown of their social and cultural patterns, and the reduction of options, fishers' traditional coping mechanisms are disappearing (UNEP 2002).

In the twentieth century, unconsciousness about sea dangers, technological progress and economic prosperity were at the base of a new maritime culture, connected to the fruition of the seashores, ground in the modern illusion of risk zero at the coast (Sauzeau 2011). But this is changing: fixing the sea edges and engineering coastal features to suit human purposes (Gillis 2012) have been causing serious problems of coastal erosion. Disasters, like Katrina and Sandy hurricanes (USA 2005, 2012) and Xynthia and Hercules storms (France 2010, Portugal 2013), show how vulnerable present societies are to sea hazards. Climate change and mean sea level rise are now a major challenge for those with responsibilities in coastal management.

4 Reflecting on Past Strategies and New Solutions

In the last decade, Portuguese governments have delegated in specialized scientific groups the study of coastal problems and the presentation of solutions. In 2014, the Littoral Working Group (LWG) was given the task to propose a set of mid-term measures to reduce risk exposure in coastal areas, taking in account the expected

climate change scenarios. The LWG's report (Santos et al. 2014), made public in that same year, analyzes the possible options: protection and retreat as mitigation strategies to avoid or reduce exposure to hazards; accommodation practices to increase population's resilience to disaster. The report points that until the 1990s the strategy more adopted was the hard protection one, through the building of groynes and seawalls. In recent years, preference has been given to soft protection, like beach nourishment and dune recovery. These infrastructures and actions have been mainly supported by EU's funds which may not be available in the future. After the identification of the major problems and vulnerabilities of the Portuguese coast—including Espinho-Nazaré coastal stretch—the LWG proposed some mitigation and adaptation measures based in protection and accommodation strategies. Those can be summarized in two main actions: sediment replenishment to the littoral (e.g. dune recovery, sand by-passing) and the adoption of urban solutions more resilient to coastal variability and flooding. The report stresses that "urban solutions based on mobile, seasonal and perishable constructions are better adapted to an environment in constant mutation" (Santos et al. 2014).

Mobility, seasonality and perishability were the main characteristics of fishers' settlements. Dolan and Walker (2004) defend that TEK can ground scientific global research framing it to local contexts, improving decision-making and adaptive capacity building at community-level. The empirical knowledge of the populations that once explored seaside resources at Espinho-Nazaré coastal stretch can provide guidance to what can be the most sustainable and effective measures in present management options to this environment. For instance, based in experience, it is possible to say that accommodation, through the adoption of urban solutions prepared to deal with coastal variability and flooding, is a good strategy. Permanent settling in the littoral should be avoided, but whenever necessary, stilt houses—like the ones already used in New Jersey's barrier islands—and small light wooden buildings are an option. If they can move accordingly to coastline changes even better. Such adaptive strategy can become a rule to new buildings and even be imposed to old ones.

Urban adaptation may have high financial costs, but it is rather consensual. However, it will not be enough. Environmental conditions have changed—in some cases radically—since the first coastal populations settled in this littoral. Until the nineteenth century this coast was covered with large dune fields. Inland progression of dunes was then a problem. Nowadays this area is being deeply affected by the lack of sediments. Urban areas are now more exposed to sea hazards than the *palheiros* ever were. Local traditional knowledge points clearly to a solution, a sustainable one. But, until now it has been very difficult to put it into practice because it raises a lot of social, economic, politic, cultural and emotional opposition. Many consider it a defeat (Gillis 2012) and no politician wants to be responsible for it. Nevertheless, science presents it as a very good long-term solution, the LWG's report recommends it and TEK fully supports it. Retreat or relocation, how it is called, is that solution. People used to do it until the twentieth century: they explored seashore resources, but lived inland or in safe places, staying away from danger (Sauzeau 2011; Gillis 2012; Mauch 2013). Relocation may be a

complicated issue when considering major coastal cities with millions of inhabitants. But, in the Espinho-Nazaré seashore, most of the urban areas at risk are small villages, once seasonal fishing camps that developed into summer vacation residential areas or become the suburbs of cities located inland or in protected areas (e.g. Esmoriz, Praia de Cortegaça, Furadouro, Torreira, Vagueira, Cova, Costa de Lavos, Leirosa). The ones connected to tourism are "ghost villages" during the winter. The traditional model could be applied here: the houses could be assembled in the summer and disassembled at the end of the season. In a long-term perspective, in face of climate change, it is more reasonable (and sustainable) to relocate than to protect these villages. Specially because history shows what happens when villages are protected with groynes and seawalls: they grow bigger as hard defensive structures provide a "false sense of security" encouraging urban expansion close to the seaside. People's vulnerability and the areas to be protected increase exponentially. The city of Espinho is the best example of this (Freitas and Dias 2015). Relocation has been proposed in coastal management plans, but only one attempt was successful (S. Bartolomeu do Mar). The LWG suggested that in some hazard-prone areas this strategy should be given priority in face of other options. Public institutions and authorities should make an example out of this solution. The future of the Portuguese coast is a politic, economic, social and cultural issue and it will be shaped not only by natural forces, but also by society's awareness and sensibility to these questions. This way communication is fundamental and local knowledge has also a role to play…

Security in the seashore is a twentieth century's delusion. It never really existed except in people's minds. History shows how recent this illusion is and reveals a different reality: the open coasts were for centuries a "landscape of fear" (Freitas 2016a). Today most coastal populations are unware of the common hazards affecting the place where they settled because most of them do not have roots there. So, they must learn about the risks, hopefully not by experience, but by oral and written transmission, through public sessions, for example. Mosley (2014) says that where less money is available to engineer solutions to natural disasters (the case of Portugal so dependent of EU's funds), resilience has to be built in the communities instead. People living by the sea must know that engineering will not fix all, because it only offers short-term solutions. USA's last century efforts to stabilize theirs shore are the best example of this (Pilkey and Dixon 1996). In Portugal, the state is still regarded as having the main responsibility concerning coastal management (O'Riordan et al. 2014). The problem is long-term planning for the coast is not compatible with the short-life of governments and their constant changing policies. Intergenerational inclusive community participation is necessary (O'Riordan 2005). Old fishers' TEK, by providing practical meaningful examples, can be used as a tool to improve communication with present coastal communities (and decision-makers), helping them to develop a new relation to the seashore, by recovering a culture of risk—the attitudes, interdictions and habits that allow to face danger—that was lost (Sauzeau 2011). If people concern only what they care, knowing the place where they live is a step forward for local capacity building and empowerment (Drew 2005, Pelkonen and Hohl 2005). Sustainability policies to be

truly sustainable must be rooted in participatory and locally grounded management practices (Veigas et al. 2014). A "culture-specific, historically informed and geographically rooted" (Berkes 2008) knowledge can provide the awareness that people need to be fully prepared to deal with coasts' natural dynamics, to respect it and to act accordingly to ensure a new cultural paradigm: the acceptance that the coasts are moving and people must move along (Gillis 2012).

5 Conclusion

Climate change is bringing new challenges to people living on the coast. Mean sea level rise is menacing populations, infrastructures, activities and ecosystems' services. Mitigation and adaptation strategies are being proposed worldwide, but solutions must be adapted to local conditions. TEK has been recognized as having an important role in grounding global science to local contexts and communities' particularities (e.g. Drew 2005; Berkes et al. 2007; Berkes 2008; IPCC 2014; Veigas et al. 2014). The purpose of this paper is to tackle these issues through the analysis of the case of the populations of the Portuguese coast. By pointing some examples of traditional local knowledge, how it can inform present coastal management options and how it can improve the communication of these matters to local actors helping them be part of the solutions.

From this study, it is possible to conclude that:

- For long, people did no settled in straight low-sandy coasts because they were too dangerous and inhospitable. Populations avoid coastal hazards by staying away from them and choosing safe places.
- Populations exploiting maritime resources developed a way of life and an empirical knowledge that allow them to cope with a mutable environment.
- Perishable mobile wooden shelters—*palheiros*—were built in the dunes. Sea fishing activities were seasonal. In the winter, fishers returned to their inland villages to work in the fields or to fish in protected estuaries, rivers and lagoons. Mobility, seasonality and perishability were their key-strategies.
- Present coastal management tries to deal with the main problems of this littoral: the vulnerability of urban areas to coastal erosion and sea flooding. Mitigation and adaptation measures such as protection and accommodation have been proposed. Relocation is lively recommended, but it has been politically impossible to put into practice.
- Based in TEK, adaptation of buildings—to make them more suitable to a changing environment—is a good solution. TEK also clearly supports the relocation option. In a long-term perspective, the best mitigation measure is to avoid sea hazards by keeping away from them.
- Moving villages inland to keep them safe must be strongly considerer in the future. Seasonal removable structures could be an option for touristic places.

Specially because history has shown that protection—the strategy more used until now—is a short-term solution and has many negative effects.

- In the coast Espinho-Nazaré most of the villages at risk are small communities, many connected to seasonal tourism activities. They have been affected by coastal erosion due to hard engineering structures—groynes and jetties—built leeward.
- TEK is important because it can help present coastal populations to have a better idea of the history of the place to where they moved in. The recovery of fishers' culture of risk may contribute to a cultural paradigm shift concerning the coasts. People must learn to live with a changing environment by moving along with it.
- Communication has a key role in this process. The transmission of long-term site specific knowledge can help removing cultural and social constraints to change. If the new inhabitants of the littoral are able to understand the uncertainty and unpredictability of their environment and learn how past communities deal with that, they will be more aware of the need of finding solutions and more willing to be part of them.

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Building Carbon Literacy: How the Irish Press Normalise Public Discussion About Climate Mitigation Actions

Brenda McNally

1 Mapping Print Media and Carbon Literacy

Broadening public engagement with climate change is a challenge for communications research, due to the complexity of the phenomenon and the urgent need for citizen action. Furthermore, post COP21, public engagement with climate change must do more than raise awareness of, or teach people about, climate *impacts* (such as extreme weather)—it also requires information about climate *responses* (such as societal mitigation actions) which involves building carbon literacy. News media have a significant role in this process, as media representations shape public knowledge of climate change and media discourse influences public perceptions and opinion. However, few studies explicitly focus on how news media report about tackling climate change or the societal efforts to reduce carbon emissions and corresponding changes to daily life and expectations. Therefore, this study contributes to knowledge about climate change communication by investigating public discussion about LCT. In particular, it targets news media treatment of LCT to shed light on the implications for carbon literacy in terms of raising awareness and knowledge about the range of processes for and public meanings of LCT. To do so, the research maps Irish press representations of LCT as a multifaceted issue—that is, as a process involving choices about a range of social, technical, financial and political dimensions. News media research about LCT as a multi-dimensional issue is crucial because how LCT is conceptualized in press treatment may involve significantly different outcomes for future environmental sustainability (Nerlich 2012).

It is generally agreed that media are powerful agents influencing public awareness, understanding and opinions of social issues. This role is particularly significant in public debates about techno-scientific controversies (Nelkin 1995) as well as discussion about global environmental change (Carvalho and Burgess 2005;

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Corbett and Durfee 2004; O'Neill 2013). However, while media analyses of climate change can reference the solutions debate and address questions about carbon literacy, to date media studies have focussed on the definitional struggle and thus news media coverage and construction of climate science. As a result, comprehensive analysis of news media coverage of LCT as a multi-dimensional issue involving options for achieving broad social and environmental change is sparse. For example, recent studies have focused on local news and energy transition in Denmark (Horsbøl 2013), low carbon housing in UK print media (Cherry et al. 2013) and climate and energy policy (Uusi-Rauva and Tienari 2010). Therefore, targeted examination of the deployment of ideas about the multi-faceted concept of LCT is an important contribution to this literature.

This study employs the concept of carbon literacy to assess press representations of LCT. There are a number of approaches to understanding carbon literacy. The term is often used by community organisations to evaluate public understanding of the social or everyday dimensions of moving to a low carbon future.[1] It is also used in transition studies in research aimed at developing 'effective communication' to improve low carbon consumer behaviour (Sharp and Wheeler 2013). In other words, where the focus is on normative or instrumental communications in which public(s) are primarily understood to be 'consumers' and the purpose of communication is to achieve private sphere engagement (Hoppner and Whitmarsh 2010). This study employs a broader definition of carbon literacy as the situated, contextual and scientific conceptualisations of LCT and knowledge about the multi-faceted approaches for moving to a low carbon future (Whitmarsh et al. 2011) and goes beyond simple information provision or knowledge and awareness of scientific facts. Thus, carbon literacy here acknowledges the socio-cultural and political implications of LCT.

As an arena for the production, reproduction and transformation of meanings about complex social issues, the habitual ideas about LCT that are normalised in media reports are highly significant. As Nisbet (citing Etzioni 2006) notes, '[o]nce assumptions and legitimate authorities are established on a problem like climate change, it becomes "costly in terms of human mental labor to re-examine what has finally come to be taken for granted".' (2013, p. x). Additionally, more people engage with media representations of transition than they do with the planning or policy process (Roberts et al. 2013). Consequently, this study maps press representations of LCT in order to understand how it shapes the range of public meanings and resources made available for public discussion about how we respond to climate change as distinct from the ways its shapes understanding and awareness of climate impacts. It argues that the public meanings about LCT deployed in print media contributes to carbon literacy and that mapping the

[1]For example, Turner (2013) claims 'it is the ability to understand the carbon implications at every scale in the landscape of our lives and lifestyles' thus involving energy consumption; transport; homes and offices.

prevalence of these press themes, can add to the toolkit of strategic communications.

1.1 Limitations and Research Constraints

As the research maps Irish press representations, the findings are not representative. However, the study targets Irish press as an important domain to begin mapping carbon literacy. Significantly, this case study offers an opportunity to examine press treatment in the context of national economic and fiscal crisis following the global banking collapse. Notably, Irish public debate about transition, tied to the need to meet EU 2020 targets, has given rise to more economic arguments for decarbonisation and approaches to carbon management. Thus, while these findings are not generalizable, they are informative for wider audiences as Ireland is at the coalface of public debates about climate responses that could occur in other countries in the future. In addition, the study does not provide insights on public uptake of press representations, which requires further empirical research. However, the findings offer nuanced starting points for audience reception studies of climate mitigation actions.

The following section describes the method employed to map the range of meanings about LCT. The evaluation focusses on how press conceptualisation reduce the complexities of LCT to the social and/or human scale. In other words, the study assesses the plurality and social (re)contextualisation of themes. The aim is to illuminate the extent to which press treatment of LCT as a multi-dimensional challenge is 'socialised' or brought closer to the lived experience. This evaluation is informed by recent scholarship highlighting the significance of the socio-cultural and socio-political dimensions of LCT (Miller et al. 2013; O'Brien and Selboe 2015) as well as information and education about socio-technical change in public engagement studies (Corner et al. 2014; Hibberd and Nguyen 2013; Hulme 2013; Whitmarsh et al. 2013). Thus the discussion also examines how trends in deployment of themes build carbon literacy, paying particular attention to how the prevalence of, and silences in, press conceptualisations influence which public meaning(s) of LCT are routinely made available. The discussion then reflects on the implications for broadening carbon literacy.

2 Method

This research builds on a pilot study of Irish press representations of LCT (McNally 2015) which thematically analysed (TA) entire articles in elite and tabloid newspapers (see Table 1). The pilot study identified six dominant themes indicating a variety of conceptualisations about this multi-faceted challenge (see Table 2) and found that LCT is an increasingly newsworthy topic (compared to studies highlighting

Table 1 Irish newspaper dataset

	Total no. of articles	Type of publication
The Irish Times	212	National Broadsheet
Irish Examiner	58	National Broadsheet
Irish Independent	28	National Broadsheet
Sunday Business Post	21	National Sunday Paper
The Mirror & Sunday Mirror**	11	Irish Edition of UK Tabloid
The Sunday Tribune*	10	National Sunday Paper
The Sunday Independent	5	National Sunday Paper
Irish Daily Mail**	2	Irish Tabloid covering UK news
Total	347	

*The Sunday Tribune closed in February 2011
**Tabloid coverage was markedly low due to large number of stories <150 words

decreasing levels of climate change stories both in Ireland (Mullally 2017) and internationally (Hope 2014). It showed that increasing press coverage of LCT highlights the need for careful consideration of the search terms employed to capture the shifting meanings of climate change, especially in the post-COP 21 context.

However, while the pilot study found that the Irish press provide a variety of conceptualisations about this multi-faceted challenge, it was primarily a broad-brush analysis. Therefore the current study examines individual references to LCT within articles. This in-depth analysis provides insights for more nuanced suggestions for building carbon literacy. Thus, this study innovates print media research of climate change by (i) employing a novel method to adequately capture the widest range of press representations and (ii) developing an original coding scheme to identify the different positions on what LCT means and/or how it is to be achieved. These are now briefly summarised.

2.1 Data Collection and Sampling

The corpus of data used for analysis was composed of all articles from Irish national newspapers available on Lexis Nexis newspaper database on 3 August 2013 and 12 October 2013. To ensure the final corpus provided an accurate account of the balance of technical, economic and social understandings of LCT, keyword searches for both expert and lay citizen conceptualisations of LCT were undertaken. The first keyword search included terms related to expert and technical discussion: 'Low Carbon', 'Decarbonisation' and 'Decarbon!'. To shed light on possible lay citizen discussions the search included the list of Creative Carbon Compounds (Koteyko et al. 2010).[2] The authors argue these compounds reduce the complexity

[2]This list contains the most commonly used words in online discussion about carbon management.

Table 2 Data sampling frame (based on press themes about LCT from pilot study)

Broad press themes about LCT (unit of analysis = entire article)	Total no. articles	Total in sample
Targets & regulations	120 (35%)	68 (35%)
Environmental concern & climate change	70 (20%)	40 (20%)
Protecting economy & costs	63 (18%)	36 (18%)
Sustainability & technological innovation	51 (15%)	29 (15%)
Negative &/or critical	38 (11%)	22 (11%)
Radical change (not incld in %)	5 (–)	5 (–)
Total	347	200 (58%)

of climate change to the human scale and they can be used to study the ways in which the issue of carbon emissions is being framed. Their inclusion resulted in a more comprehensive dataset and therefore increased the value of the research findings.

The searches covered the period 1 January 2000–31 July 2013. This timeframe marks the early stages of Carbon Tax debate in Ireland up to the end of the Irish Presidency of the EU and final discussions of EU policy on LCT. The news organisations were chosen to provide a good cross section in terms of type of publication and ideological orientation and included broadsheets, tabloids and weekend editions. Articles selected were from across the spectrum of newspaper sections but excluded articles of less than 150 words and Letters to Editor as these were considered too short for analysis. After screening and removal of duplicates this yielded 347 usable articles. A sample of 200 articles (approx. 60% of dataset) was then drawn-up using random stratified sampling based on prevalence of themes in the pilot study (see Table 2).

Thematic Analysis (TA), Codebook Development and Coding Strategy

The coding scheme categories were developed inductively following steps for TA outlined by Braun and Clarke (2006) and the coding process was carried out using nVivo software. TA is a particular type of qualitative content analysis that focusses on identifying recurrent ideas or themes in texts (rather than words). The TA was theoretically informed by the concept of framing from media studies. 'Framing fundamentally asks how an issue is made meaningful' (Horsbøl 2013, p. 25). This was operationalised in the coding process using Entman's definition (1993, p. 52) news frames are 'manifested by the presence or absence of certain keywords, stock phrases, stereotyped images, sources of information and sentences that provide thematically reinforcing clusters of facts or judgements'. Thus, categories generated by drawing on the concept of framing are essentially dominant themes about what LCT means, involves or requires; or repeating patterns of ideas about the problem LCT solves or the processes for decarbonisation. Consequently, this approach to framing produces fine-grained insights suited to developing communications strategies.

Table 3 Prevalence of Irish Press themes about LCT

Press themes about LCT	Prevalence (% of total references 1063)
State/sectoral intervention and regulations	299 (28%)
Financial and market measures	174 (16%)
Economic growth and efficiency	130 (12%)
Environmental responsiveness	114 (11%)
Citizen responsibility and consumer action	111 (10%)
Advocating energy transition	109 (10%)
Techno-innovation & low carbon solutions	92 (9%)
Future scenarios	32 (3%)
Miscellaneous	2

However, it is important to note that the identification of particular frames does not imply that audiences will interpret their content in the manner described or that press frames influence audience attitudes or behaviour. Likewise, the study does not include important insights from news sources who are highly influential in news reporting about technoscientific debates (Anderson 2009; Maeseele 2010). Finally, whilst informative, Irish press themes do not necessarily reflect the representations of LCT across broadcast and online media.

3 Trends in Irish Print Media Themes About LCT

The inductive TA generated 8 themes about carbon literacy (see Table 3). All the references to LCT were coded and the process allowed for the same unit of text to be included in more than one theme. This resulted in 1063 references across the study sample.

3.1 State/Sectoral Intervention and Regulations

> Her colleague, Liz McManus, said the proposed Bill was inadequate and that overall responsibility for the targets should rest with the Taoiseach, as recommended by a report she prepared for an Oireachtas committee.
>
> Climate change Bill to formalize emissions targets, Irish Times, 12.12.09

The most prevalent conceptualisation represents change as taking place through orderly top-down procedures which is at odds with generally accepted ideas of transition as disruptive and involving intermediaries (Geels and Kemp 2007) and analysis that claims 'socio-tech systems emerge haphazardly, unpredictably and from left field' (Urry 2011, p. 160). Significantly, as Stirling (2015) argues, the history of social and technical transformations suggests that change occurs in more

'horizontally distributive forms, with hope-inspired collective action, social mobilisation and democratic struggle playing more dominant roles' (ibid., p. 2). Therefore, the prevalence of this conceptualisation obscures the wide diversity of stakeholder and citizen interests that are necessary for the 'horizontal politics' associated with societal transformation. This category notably features calls for 'transformative leadership' and/or 'radical transformation', but beyond calls for these processes, there is no critical assessment of what this transformation might involve. While this conceptualisation brings climate change home as a local issue, it primarily focusses on evaluating local policy-making and critical assessment is restricted to discussion of government (in)action particularly around the Carbon Tax and Climate Change Bill.

3.2 Financial and Market Measures

> During the Celtic Tiger years, Ireland's greenhouse gas emissions spiralled out of control and it was speculated that the Government might have to spend more than EUR1bn in purchasing carbon credits to comply with Kyoto.
>
> We've turned the gas down, The Mirror, 23.10.10

This theme offers statements about financial solutions and generally promotes establishment actors' views on the economic utility of the Carbon Tax, Energy Tax and Carbon Markets. However, these are often decontextualized from references to environmental protection or social concerns. Thus, the primary concern is identifying the most cost-effective ways of meeting targets and reducing carbon emissions. As critics point out, this assumes status quo practices and values can be left unchanged and existing social arrangements do not need to be altered (Blue 2015). One of the most repeated references is to 'putting a price on carbon' as the 'tough measure' that will reduce (environmental) pollution, incentivise behaviour change and address need to meet Kyoto targets. This category also frames the public meaning of LCT within the logic of efficiency and promotes discussion of carbon calculus over societal transformation or questions about social distribution, ethics or consumption. It also avoids discussion of the 'systems' which create pollution and the contribution of markets and technology to the problem. Thus it places blame on citizens and businesses for creating emissions rather than the capitalist modes of production and consumption. In doing so it advances simplistic evaluations of financial measures, which are at odds with the complexity and scale of the problem.

3.3 Economic Growth and Efficiency

> The debate has moved on from one of strict compliance to reduce greenhouse gas emissions and increase the share of renewable energy, to a much more strategic discourse about how Ireland must prepare to become a low-carbon economy. We need to identify and plot a

> sustainable and affordable pathway to transition Ireland as a low-carbon country; but even more to be a world leader where we have a natural competitive advantage.
>
> We have potential to be world leaders in the green economy, Irish Independent, 1.12.11

This conceptualisation advances two perspectives on LCT both of which set the terms of debate within an economics and technology framework. The first, prior to Irish economic collapse in 2008 is critical of LCT and questions the economic value of the carbon tax and the costs for business. Post-2009 this category presents economic crisis and the need for regrowth as the main problem and describes the economic benefits of LCT. As a result, this category omits references to environmental protection or concern and asserts economic utility as the paramount paradigm for evaluating LCT. Overall, it advances public knowledge of the benefits of a low carbon economy with some critique of financial measures and 'onerous targets' on national competitiveness. This is highly significant in relation to shaping carbon literacy and public knowledge about the trajectory of transition pathways. As Nerlich (2012) points out, how the problem of transition is framed and discussed, influences which solutions are seen as possible and thus who are viewed as the responsible agents of change. Additionally, there is little discussion of social inequity or distribution issues associated carbon reduction activities or any questioning of consumption. Instead, this category promotes elite rationales for reducing carbon emissions such as concerns about carbon tax and maintaining farming production.

3.4 Environmental Responsiveness

> ECONOMIC RECOVERY when it comes must involve Ireland developing a low-carbon smart, green economy, the Environmental Protection Agency (EPA) said yesterday. 'Launching the agency's annual highlights for 2008, EPA director general Dr Mary Kelly said the environment was an asset under threat and early warnings about the potentially catastrophic effects of climate change must be heeded.
>
> EPA calls for move to low-carbon economy, Irish Times, 3.04.09

This is the only theme to explicitly link LCT and climate change. However, it advances a number of positions on LCT and the environment and possibly represents the most distinctly Irish conceptualisation of transition, specifically in relation to highlighting inherent tensions involved in balancing economic and environmental rationales for LCT. Two views stand out: firstly, that environmental protection is too costly and will reduce national competitiveness and secondly, following the Stern report, arguments challenging earlier negative economic pronouncements on LCT and tackling climate change. Other references focus on the costs of climate change impacts and CO_2 emissions penalties; calls for Climate Change law as well as the advantages of Ireland's low carbon farming model. Thus this category promotes the logic of efficiency with claims that 'climate policy can be

consistent with good economics' and references to 'win-win solutions' as well as vague environmental rhetoric calling for 'imagination, innovation and new ways of working' but more often dramatic fear appeals emphasizing the need to 'save the planet'. It also draws on carbon calculus to legitimise food production goals and increasing agricultural emissions ahead of meeting climate targets. However, while linking economic crisis and environmental catastrophe presents some of the complexity of LCT, it lacks social critique. For example, there is very little discussion of the social impacts of LCT initiatives and the role advanced for citizens are primarily as carbon conscious consumers.

3.5 Advocating Energy Transition

> There is more to it for Ireland than reducing emissions, however important that may be. The country has world-class renewable resources in abundance – wind and water being the two obvious examples – but has yet to determine how best to develop these assets and the potential scale of the investment.
>
> We have potential to be world leaders in the green economy, Irish Independent, 1.12.11

This category promotes energy transition as the solution to energy security and a valuable contribution to economic rejuvenation, through the development of new green industries which will create 'thousands' of jobs. As a result, energy transition is discussed as a topic which affects everybody and is often personalised with references to impacts and benefits for farmers, households and commuters. Despite this however, discussion of clean and renewable (energy) technology is generally divorced from references to environmental protection, tackling climate change or the social dimensions of energy change. Likewise references do not question energy consumption, the reality of the high carbon lock-in of our lifestyles, or promote societal responsibility. Instead, it prioritises the view that the only thing that has to change is the type of energy we use, rather than how much we are consuming. This conceptualisation also pays considerable attention to energy policy, infrastructure change and the most economically beneficial methods of energy generation, all of which are presented in techno-managerial language. Given that energy permeates everything we do, the lack of social (re)contextualisation is highly significant for carbon literacy as it makes energy policy invisible and thereby reduces public agency and ability to act to create change.

3.6 Citizen Responsibility and Consumer Action

> The Governmental commitments under the Kyoto protocol are only a start. Every person has responsibility to reduce their carbon footprint, and this must be done quickly now that the very obvious effects of climate change are upon us.
>
> Wiping your carbon footprint clean, Irish Times, 19.09.08

This is one of the two 'socially relevant' conceptualisations of LCT (see also 'Future Scenarios') and as expected, it presents a wide-ranging discussion relevant to citizen involvement with LCT, including references to political engagement, linking action to the causes of climate change as well as questioning consumption and societal distribution and inequity. However, references are generally framed within the logic of efficiency and the focus on behaviour change constructs individuals as the problem rather than high carbon lock-in. It also avoids discussion of systemic or structural problems and the causes of climate change or references to barriers to citizen and community action. In addition, although references are made to the need to change everyday lifestyles, they omit advice or evaluation directed at specific societal groups such as families, teenagers, mothers, fathers and thus fail to personalise the issue for readers.

3.7 Techno-Innovation and Low Carbon Solutions

> The EPA says these targets will be met because of improvements in the energy efficiency of homes and more fuel-efficient cars, including the rollout of electric vehicles.
>
> Recession fuels 'unprecedented' fall in emissions, Irish Independent, 23.10.10

This theme presents a constructive view of technological innovation as the means of achieving LCT with considerable discussion of how it will contribute to the low carbon economy. References repeatedly highlight the benefits of sustainable development especially clean and green energy as economic drivers. A second dominant idea promotes the efficiency of low carbon production associated with Irish farming and related expert concerns with measuring and validating carbon reduction. As a result, this category is also driven by the logic of efficiency, which highlights the production of economic benefits in environmentally friendly ways. The predominant view is of unproblematic technological advance—technology will address carbon reduction needs and citizens are positioned as unproblematic consumers of new low carbon products.

3.8 Future Scenarios

> We need to be thinking about the creation of a new transformational approach, involving a mutually beneficial partnership between business and Government, which will be in the long-term interest of current and future generations, she added.
>
> Nation can become 'global hub for carbon credit trading', Irish Examiner, 10.03.09

The marginal presence of this theme offers stark illumination of the extent to which the social dimensions of LCT are marginalised in press representations. Moreover, despite its potential to represent social concerns and aspirations, press treatment of this category offers a vague vision of a low carbon future dominated by

elite claims-maker interest in LCT. Thus it offers few references to what a *future society* should or could be like, or discussion of 'the constellations of social forces that might bring about such transition' (Urry 2011, p. 140). This is significant for carbon literacy because it indicates that the underlying assumption reproduced in press treatment, is that LCT will not be driven by social forces, but rather by government/sectoral intervention and financial solutions. In addition, the deployment of ideas about a carbon constrained world is confined to establishment rhetoric which paints an optimistic economic vision of 'profound change' uniquely devoid of any social implications of technological transformation.

3.9 Implications for Building Carbon Literacy

The analysis reveals that press treatment inadequately represents LCT as a local issue and fails to bring LCT closer to the lived experience, which is a key concern of emerging literature on public engagement with LCT (Bulkeley et al. 2011; Rowson and Corner 2015). Instead, the prevalent conceptualisations help to define a vision of LCT that is separate from discussion of the social and cultural implications and the need for social transformation. This has negative consequences for carbon literacy as it reduces ability of citizens to make informed choices about LCT, specifically in relation to seeing beyond economic priorities and fulfilment of individual interests.

The findings also highlighted the extent to which Irish press treatment normalises public meanings of LCT as involving unproblematic linear change, which is at odds with the history of transitions as unpredictable, messy and driven by intermediaries beyond elite and/or establishment actors. Thus, the study argues that Irish press treatment narrows the visibility of carbon as a social, material and cultural issue and that this was accomplished through a number of discursive tactics, notably (i) by employing the language and logic of elites; and (ii) the 'crowding out' of socially relevant topics and associated with this, a lack of social critique.

Perhaps the most distinctive feature of Irish press treatment is its focus on 'Financial and Market Measures' (16%) over 'Technological Solutions' (9%). The relative silence in press treatment of technological dimensions differentiates the Irish case from comparable studies of print media and LCT. However, discussion of the processes for tackling climate change is potentially one of the most important for shaping carbon literacy as it contributes to public debate about the alternate choices for achieving LCT. Furthermore, references to solutions are predominantly utilitarian, repeatedly focussing on what they will achieve and incentivising behaviour change rather than on the problems they may create or the socio-cultural and political implications. In particular, the negative implications of financial or market measures for society or discussion about societal impacts of technical innovation is seldom raised. In addition, the focus on financial and market measures, which promotes responsibility at the level of liberal markets, leaves unasked

and answered questions about consumption. Likewise, references rarely challenge the limits of technology in relation to the scale of the problem, the reality of 'green growth' or the viability of linear progress espoused by establishment figures. As a result, Irish press treatment offers little in terms of informing democratic struggle and political engagement with LCT and therefore presents a reductive and banal account of possible transitions pathway.

3.10 Suggestions for Communications and Journalism Praxis

The findings show that rather than broadening the conversation about LCT and adding to public resources for talking about climate responses, the Irish press normalise narrow public meanings and ideas about actions. In particular, it asserts the agendas, preferences and framings of LCT in line with powerful business and political actors. These limitations on plurality and social (re)contextualisation pose challenges for building carbon literacy and potential cognitive engagement with LCT.

The most important findings arising from this analysis however are its insights on the value-laden nature of press treatment of LCT and the implications of the lack of social critique. The findings illuminated how the dominant themes prioritise and reproduce existing patterns of social activity, thus promoting public knowledge of LCT as a process in which existing social arrangements are maintained rather than an opportunity for radical social transformation as called for by Hulme (2015) among others. Moreover, Hulme argues the focus on 'carbon calculus' normalises carbon management as 'trust in numbers ahead of justice on the ground'. Thus, the problem with the expert-driven calculative approach to LCT that dominates Irish press treatment is that

> it acts as a proxy for ethical choice and avoids or replaces discussion of 'the pressing needs of wealth re-distribution, human welfare and social justice' (ibid.).

By prioritising LCT as a government responsibility, Irish press treatment frames the challenge as 'a matter best left to technocratic decision making and/or market forces' (Maeseele 2015, p. 398) and may therefore be said to impede democratic debate by contributing to processes of de-politicisation (ibid.). Thus, Irish press discussion of LCT primarily places responsibility for most of the difficult ethical, cultural, political and economic questions in the hands of politicians and, increasingly, business interests to work out. Overall, the analysis highlights the influence of elite interests in shaping carbon literacy and thus how powerful claims-makers establish their perspective on potential citizen action associated with LCT. This indicates the need for journalism praxis to present a range of new voices and alternate visions on LCT as this could broaden carbon literacy in new creative ways. It also underlines the need for communications strategies to challenge the dominant business-as-usual narrative and offer alternate insights. In particular, the

findings highlight need to (i) focus on social and local dimensions, and increase awareness of transition as a socio-cultural and political issue and (ii) translate techno-managerial and abstract language to more socially-relevant information.

4 Conclusion

While there is agreement about the need for greater public engagement and public talk about climate change, less is known about what this talk should involve. Analysing news media and press representations of LCT in terms of building carbon literacy offers novel insights for research and communication strategies aimed at engaging publics with responses to climate change. This study shows that rising Irish press coverage of LCT may constrain the possibilities for more diverse public talk about climate mitigation action, which has implications for broader public engagement. However, audience reception studies are needed to confirm whether this is the case. Additionally, future research should examine whether the patterns of press coverage identified in this study are replicated in other countries.

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Climate Change Communication and User Engagement: A Tool to Anticipate Climate Change

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1 Introduction

Climate change, its causes and impacts have received considerable attention since a couple of decades (van Alast 2006). The already observed changes in climate, especially warming trends, are projected to become more apparent and severe at the end of the century (IPCC 2014a). However, although less attention has been put in the medium-range climate changes, climate is already changing now and adaptation is therefore unavoidable, becoming an immediate priority across many sectors (Füssel 2007). The time horizon for climate adaptation can vary from a few months to many decades. Some aspects of climate change can be predicted with reasonably high confidence in the medium-range (e.g. changes in average temperature) whereas others are associated with larger uncertainties (e.g. changes in hurricane tracks and intensity). The list of climate-sensitive sectors includes agriculture, forestry, energy, water management, public health and insurance, among others. Planned adaptation to

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climate change means the use of information about present and future climate conditions to review the suitability of current and planned practices, policies and infrastructure (Thomson et al. 2006; García-Morales and Dubus 2007). Adaptation planning involves therefore addressing questions about how different future climate conditions will be from those observed in the past. According to that, adaptation measures aim at finding a balance between the risks of acting too early or too late to adapt to the future climate change conditions. Depending on the specific sectors, adaptation to climate change may have close links with natural resource management, sustainable development, disaster preparedness or urban planning (Füssel 2007).

Increasing temperatures, decreasing water availability, and a growing frequency of extreme events can, independently or in combination, have many implications for the different economic sectors (IPCC 2014b). Uncertainty about how these aspects are likely to be in the next months or seasons makes difficult to anticipate economic risks for climate-sensitive sectors (Goddard et al. 2010). Here is where climate predictions in the medium-range time horizon have a role to play. Although they cannot be as specific as weather forecasts (which can tell the temperature for tomorrow or how much rain to expect with high accuracy), climate predictions can provide probabilistic information about the likelihood of occurrence of certain outcomes. That is, the probability of experiencing cooler, normal or warmer than average temperatures in the upcoming months with useful skill. This is because the basis for climate prediction lies in components of the climate, such as the ocean and the land surface, that vary slowly compared to individual weather events (Doblas-Reyes et al. 2013).

The concept of climate services arose with the aim of making climate predictions user-oriented (Street 2016). Climate services refer to the transformation of climate-related data, together with other relevant information, into customized products that may be of use for the society at large (Street et al. 2015). In this way, predictions, trends, economic analyses, or counselling on best practices are considered climate services. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management.

Although the use of climate services in the business sector is far from being generalized, they have recently been suggested to be capable to provide additional value for the renewable energy and the re/insurance sectors, among others. Even though these sectors do traditionally use historical records of past events to inform current risks (e.g. Landberg et al. 2003), this practice is changing as climate change is likely to affect the regularity and intensity of extreme events. For example, understanding and quantifying the change in wind resources in the next season is a key factor, since this information can support the wind energy sector when taking decisions on energy production, as well as other management actions, ahead of time (Torralba et al. 2017, Lynch et al. 2014; Troccoli 2010). There are emerging opportunities of climate predictions to be used by re/insurance companies, including those that specialize in business interruption, life insurance, agriculture and other areas where the potential risk is changing. Indeed, the changing risks between the recent past and the not so distant future are of great interest to the re/insurance sector because even slight changes in climate characteristics can translate into large impacts on the risk management and expected losses (Botzen et al. 2010).

While the insurance and the renewable energy sectors are starting to deal with probabilistic predictions in the medium-range, the application of these predictions to agriculture still sees many challenges, since attention in this sector has been traditionally focused on short-term weather forecasts (up to 2 weeks) and climate projections (20–100 years). However, results obtained in previous studies concerning the wine crop reveal that adaptation measures at the sub-seasonal and seasonal scale are increasingly given a higher priority (Neethling et al. 2016; European Commission 2016).

1.1 The Role of User Engagement and Communication in Climate Change Adaptation

To make adaptation to climate change effective, the different climate-sensitive sectors need to be aware of the problem they are facing. At this stage, the climate service community is responsible of assessing and communicating the vulnerability to climate change to the climate-sensitive sectors. Thus, establishing an understanding of the user decision-making process is key to ensure that the climate service will be tailored to the user needs. In doing so, it is recognized that climate is often not the most important issue to users and that sometimes more effort should be put in identifying users' sensitivities, thresholds and risk tolerances related to climate within the user decision-making (Davis 2012).

A continuous interaction with users is central for their effective engagement, where communication, co-design, co-production and co-evaluation are important (Street 2016). At the beginning of the interaction, users often ask for climate information tailored to a near-exact time and place. However, climate predictions cannot provide this level of detail, and it is important to make the user understand that the provided climate information illustrates broad changes, representing the variation of climatic conditions over a time period longer than hours or days. Similarly, the usefulness of typical climate predictions at coarse spatial resolutions is very limiting for some users that need finer information for a specific location. This aspect is currently being approached by the climate science community, for example through statistical downscaling methods, where a statistical relationship is established between observations and simulated large-scale variables, like atmospheric surface pressure (Jones et al. 2011). Due to its probabilistic nature, climate information often can be perceived as untailored, unintuitive, hard to understand and therefore difficult to apply in decision-making contexts (Bruno-Soares and Dessai 2016). Therefore, communicating the uncertainty of probabilistic climate predictions needs to be done effectively, so that users can clearly understand and apply climate services to their decision-making while managing the potential risks and opportunities of future climate variability. To help with that, the climate science community is currently working on translating climate services into cost savings for the climate-sensitive sectors (Christel et al. 2016).

1.2 The Role of Visualization in Climate Change Adaptation

The appropriate development of graphical visualizations to communicate climate data is fundamental to the provision of climate services to guide climate change adaptation decisions (Daron et al. 2015; Kaye et al. 2012). Graphical visualizations are necessary to spread climate information and products beyond the developers' community, helping the user to interpret and use the information as simply and quickly as possible (Christel et al. 2017). In addition, the spread of climate information needs to be done in ways that are effective and also attractive. In this way, awareness of the potential application of seasonal forecasts is raised and probabilistic information is put into a usable form for decision-makers. However, designing intuitive and meaningful visual representations in the climate context faces a variety of challenges, from the heterogeneity of climate-related data (e.g. spatial, temporal, multi-variate…) to the heterogeneity of user groups (e.g. users with different skills, interests, knowledge…). Despite the emergence of climate services and the increasing use of online platforms to disseminate climate information (Australian BoM 2016; IRI 2016; IPCC 2016), there is still limited empirical evidence of how different individuals and sectors interpret different visualisations of climate data.

Climate-sensitive sectors are often reluctant to use medium-range climate predictions because they do not fully understand their usefulness and application. The improvement of communication strategies is therefore fundamental to stimulate the use of climate predictions within decision-making processes, which requires providing information about the opportunities and limitations of this type of information. Taking a list of recommendations for the visual communication of climate predictions to users as a departing point (Davis et al. 2016), this work describes how these recommendations have been integrated in the co-production process of different climate services. Through practical examples involving climate services for agriculture, renewable energy and insurance, this study aims to illustrate the importance of user engagement and science communication to adapt to medium-range climate change. The aim and design journey of each selected climate service is described. The given examples encompass both the visualization and description of climate data, which can help deliver a clear message to climate-sensitive end-users.

2 Climate Services for Climate Change Adaptation

This research arises from a previous study (Davis et al. 2016) and from our experience with users, which allowed us to identify the challenges regarding the visual communication of climate predictions to users and decision-makers of climate-sensitive sectors. Often, different techniques are used to communicate climate information, and this can be confusing for the users, who may interpret

information very differently and have diverging expectations regarding the amount of risk they are willing to take. Moreover, there is a gap between the scientific data available and the information needed for decision-makers to adapt to climate change (Asrar et al. 2013). Therefore, training on how to interpret probabilistic information, tailored visual interfaces or information centers are helpful to connect the providers of information and the user needs in the face of climate change. The results presented in Davis et al. (2016) suggested that decision-makers could benefit from improved accessibility, communication and understanding of climate predictions if certain recommendations are followed. The following sections describe how some of these recommendations have been incorporated in the design process of three climate services aimed at helping climate-sensitive sectors to anticipate and adapt to medium-range climate change.

2.1 Climate Services for Agriculture

2.1.1 What?

Participatory approaches such as consultation, product co-design and promotion of interactive events are useful to engage different stakeholders, improve adaptive capacity and inform adaptation measures in agriculture (Adger 2003, Bojovic et al. 2015). Establishing a bi-directional communication between users and producers of climate information is a prerequisite for the development of effective climate services (Street 2016). SECTEUR https://climate.copernicus.eu/secteur, a EU Copernicus Climate Change Service (C3S) project, is taken here as a practical example of the application of participatory tools in user engagement and co-production in the field of climate services. The SECTEUR project involves researchers working together with private and public sector organizations to understand their climate data requirements with the aim to deliver better-tailored information that supports decision-making. Agriculture and insurance are two of the climate-sensitive sectors covered by the project. In the case of agriculture, working directly with winegrowers allows focusing on technical feasibility, market needs and gaps faced by the wine sector that could be filled with additional research by the scientific community.

2.1.2 How?

The project is engaging and interacting with a wide number of organizations through a survey and various workshops that help establishing an inventory of existing needs and user requirements in terms of climate data and climate impact indicators (Bojinski et al. 2014). For agriculture, climate predictions about how the growing season of the wine crop is likely to be (e.g. drier than normal, normal or wetter than normal) are useful for winegrowers, because the sooner they can plan

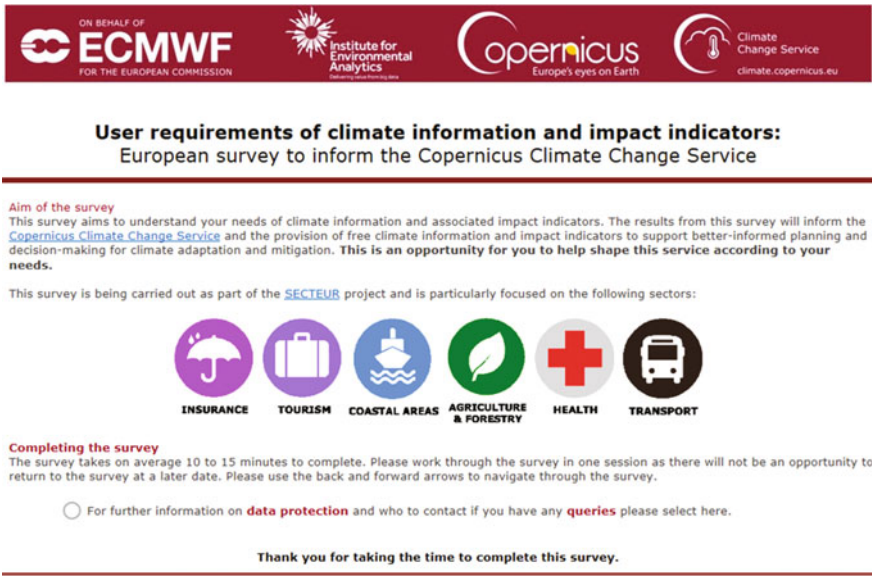

Fig. 1 Landing page of the SECTEUR participatory tool to gather information on user requirements of climate information and impact indicators for each of the climate-sensitive sectors involved in the project

their decision-making, the better they will be able to prevent the deleterious effects of extreme climate events. For example, if a dryer than normal season is expected, a wine producer can decide to maintain a thicker canopy in grapevines in order to retain humidity and protect the plant from excessive evapotranspiration. On the other hand, if the season is predicted to be exceptionally wet, and if economically feasible, the winegrower can decide to reduce the canopy to decrease disease effects by fungi, or take other decisions such as the acquisition of fungicides in advance.

Results from the SECTEUR survey (Fig. 1) were not available during the preparation of this manuscript. However, some requirements of climate information from different users in the wine production chain were identified in a workshop devoted to the wine sector. Wine producers and irrigation consortia identified mean temperature and mean precipitation during the growth cycle of grapes as useful in regions where forecast shows skill for the selection of varieties, the definition of dates for managing practices, or the estimation of crop yields. The research community pointed at a need for more detailed data. Variables such as daily temperature, precipitation, wind and relative humidity are used to simulate the grape growth and other variables involved in this process, such as evapotranspiration or soil water balance. In the case of environmental agencies, indices like the drought index (Hayes et al. 2011) are useful to develop climate scenarios for mitigation strategies as well as to advice farmers on best practices.

2.2 Climate Services for Energy

2.2.1 What?

The visualization tool project Ukko (http://project-ukko.net/) is a prototype for wind energy developed within the framework of the EUPORIAS project (www.euporias.eu). The tool provides robust information on the future variability of the wind resource based on probabilistic climate predictions. With the aim to raise awareness of recent advances in medium-range climate predictions, the prototype puts probabilistic information into a usable form for decision-makers in wind energy. It addresses multiple user profiles in the wind energy sector, from operations and maintenance teams to grid operators or energy traders. The tool has been developed by an interdisciplinary team made of climate scientists, data visualization specialists and designers that provided complementary perspectives. Using engagement and communication channels, the design of the prototype reached various audiences and attained high levels of visibility (Christel et al. 2017).

2.2.2 How?

The visualization tool uses data on 10 m wind speed obtained from the seasonal prediction system (System 4, Molteni et al. 2011) of the European Centre for Medium-Range Weather Forecasts (ECMWF), which produces a climate forecast using 51 ensemble members. An ensemble corresponds to a group of simultaneous climate simulations characterizing climate predictions that are conducted using slightly different initial conditions.

As a result, the online tool presents a map with seasonal wind predictions visualized with line symbols that represent the predicted wind speed through line thickness, the forecast quality (representing the quality of the forecast system) through opacity, and predicted trend of wind speed through line tilt and colour (Fig. 2, legend on the right). Trend in wind speed is displayed as the likelihood of wind speed falling in each of the following categories in the coming months: normal wind (about average wind speed for the region), below normal wind (low wind speed for what is usual in the region) and above normal wind speed (high wind speed for what is usual in the region).

Project Ukko consists of a global map with a data overlay designed to enable users to quickly detect global patterns and trends in future wind conditions. This display allows drawing the user's attention immediately to the areas with larger probabilities of significant changes in wind speed. Following the well-known visual mantra of overview first, zoom and filter, details-on-demand (Schneiderman 1996), the user can also drill into detailed prediction breakdowns at a regional level.

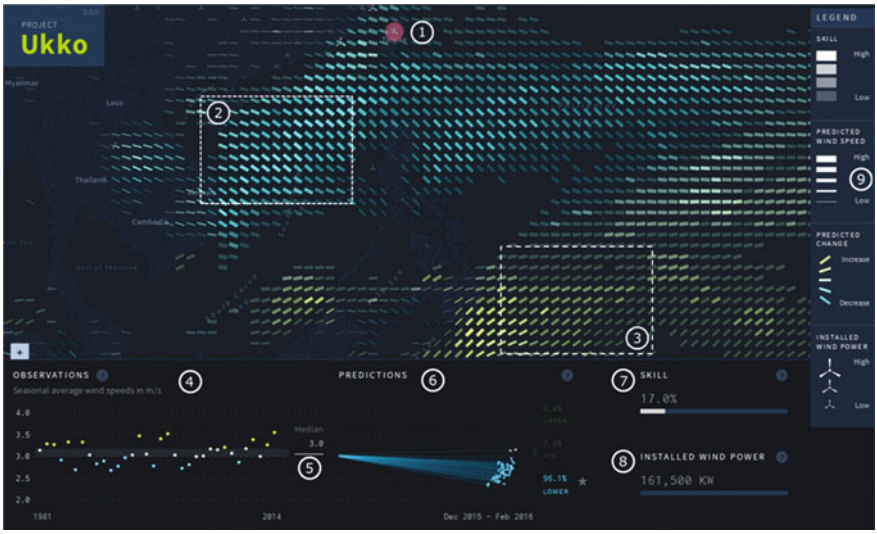

Fig. 2 Project Ukko data visualization tool and results for the predicted season (December 2015–February 2016): 1—selected geographical region, 2—area of high probability of reduced wind speed compared to climatology, 3—area of high probability of increased wind speed compared to climatology, 4—seasonal average wind speed in the selected geographical region over the last 30 years based on the ERA-Interim reanalysis, 5—median wind speed over the last 30 years based on ERA-Interim, 6—wind prediction for the next season (the percentage of simulations in each of the terciles gives the probability to lower, equal or higher than normal wind speed conditions), 7—skill or measure of how well the prediction system has performed over the last 30 years in the selected region, 8—currently installed wind power in the selected region, 9—legend of symbols used in the visualization (skill: opacity, predicted wind speed: line thickness, predicted wind speed trend: line tilt and colour, installed wind power: wind turbine)

Selecting a region on the map opens a panel with additional information (Fig. 2, bottom), including the past 30 years of wind observations, the full distribution of prediction results from the 51 ensemble members for the specific predicted year, the skill level and the current wind power installed capacity in the selected region. As seasonal predictions are probabilistic, they give the probability of occurrence of certain outcomes rather than a single 'yes-no' deterministic prediction. For this reason, having an idea of the full distribution of ensemble values is important to fully understand and read a given prediction. A visual representation of a cone of rays—the probability cone (Fig. 2, #6), emanating from typical (median) value of the historic data (Fig. 2, #5) was designed to communicate probabilistic information in a simple way (using the x axis as a conceptual time line from the past to the future prediction).

2.3 Climate Services for Re/Insurance

2.3.1 What?

The website Seasonal Hurricane Predictions (www.seasonalhurricanepredictions.org) is an online platform that brings together predictions from different centres that specialize in Atlantic hurricane forecasting (including universities, governmental agencies, private companies and other organizations as sources). It has been developed by an interdisciplinary team of scientists, graphic designers and visualization specialists in close collaboration with a global re/insurer. The platform has the objective to track seasonal hurricane predictions and the evolution of hurricane activity, which officially runs from the beginning of June to the end of November, and to make them available to both advanced users and non-specialists. On the one hand, the website offers extensive information to promote understanding of the factors that contribute to these meteorological phenomena, with devastating consequences, and to help explaining why different seasonal forecast models can produce different predictions. On the other hand, sections offering scientific content, such as model details or the possibility to download data, are directed to advanced users. The platform provides information of special interest for the re/insurance sector, which uses seasonal hurricane predictions not only for model validation or risk assessment but also in aspects of their decision-making. To date, the platform is displaying predictions from 21 different forecast systems and it is open to any centre interested in participating.

2.3.2 How?

Predictions from the different forecasters are collected through an online form that each of the centres needs to fill every time they have a new prediction and want to display it in the website. Predictions issued in March–April, May–June and July–August are individually submitted online. Whereas some centres only issue a prediction for the whole season, other centres provide additional predictions as the season progresses. This is important to consider, since the closer to the hurricane season, the better the prediction should be. The last predictions provided by each forecaster are regularly averaged to compute the number of hurricanes that are expected to affect the North Atlantic basin in the upcoming season. The range of the prediction is given by the minimum and the maximum of the individual submitted predictions. The level of activity of the predicted hurricane season (low, medium and high) is indicated by a colour code according to the limits defined by NOAA (2016). The selected colour scale is readable by colour-blind users. A yellow hurricane symbol indicates that the level of activity for the hurricane season is predicted to be low. If the hurricane symbol is orange, it indicates that there is a medium level of predicted hurricane activity, whereas a red hurricane symbol indicates that the level of predicted activity is high. Apart from the predicted

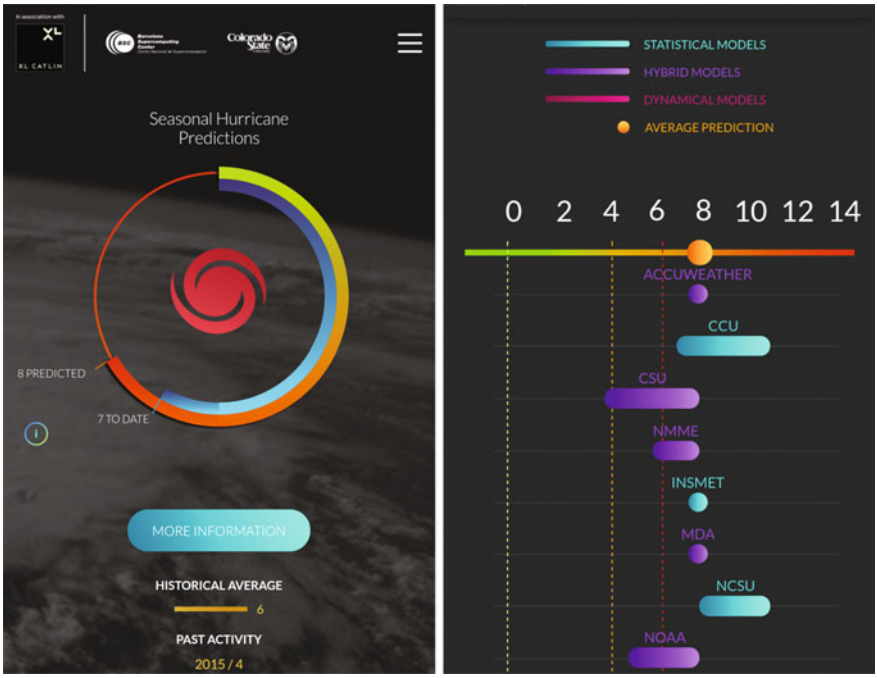

Fig. 3 Seasonal Hurricane Predictions data visualization tool for mobile devices with the results for the predicted hurricane season (June–November 2016). Left: homepage with the number of hurricanes predicted (8 hurricanes), the number of hurricanes that occurred to date (7 hurricanes), the hurricane symbol in red, indicating high hurricane activity, the historical hurricane average since year 1966 (6 hurricanes/season), and a list with the past activity per year since 1966 (shown when scrolling down). Right: panel for advanced users that opens after clicking on "More information" on the left image with the predictions from the individual forecasters in different colours according to the type of model. The average prediction is shown by the orange ball, and the dotted lines from left to right correspond to the limits for low, medium and high activity defined by the NOAA

number of hurricanes, the actual number of hurricanes that have occurred to date in the current season is also shown. In addition, the hurricane activity in previous years (since 1966) is reported. This information can be useful to put the current prediction in context for the different media because it is usually considered a valuable information resource.

The website contains not only predictions of hurricanes but also for other variables like major hurricanes, named storms and accumulated cyclone energy. A graph is displayed for each variable, where the predictions provided by each centre are displayed according to the type of model applied (Fig. 3, right). Considered model types are statistical, dynamical and hybrid, and they are represented in different colours in the graphs. Note that when the mouse hovers over a particular prediction, other predictions from the same forecaster issued in other months are also highlighted to allow the comparison and assessment of the prediction evolution through time.

2.4 Opportunities for Climate Change Adaptation

Applying participatory and visualization tools in climate services development can help shape effective products, but their application also faces challenges (Table 1). The climate services described in this work are the result of a co-production process with users from the agriculture, wind energy and insurance sectors. Whereas the users provide information about their needs and types of decision-making to help tailoring the service to their specific requirements, they also express a need to get clear information that helps them to understand how to handle prediction uncertainty with confidence (Otto et al. 2016).

According to users in the agriculture sector, climate change adaptation in the medium-range involves taking decisions during the growth cycle of grapevines. Each step of this process plays an important role in the development of grapes with ideal characteristics for wine making. Viticulture practices such as canopy management, irrigation, or the use of agrochemicals are applied differently by users according to the grape variety and the *terroir* (concept that involves factors like climate, soil type and geomorphology). These practices, directed to optimize the quality of wine and grape trading in the market, are strongly related to climate variability. Medium-range climate predictions have been identified in previous studies to be useful for adaptation to climate change (Neethling et al. 2016; Soret et al. 2016), and this idea is reinforced by the workshops conducted as part of the SECTEUR project.

According to users from the wind energy sector, climate change adaptation in the medium-range involves taking strategic decisions related to renewable investments and integration of wind energy into the energy grid system, which is intricately tied to the variability of climate (Davis 2012). Any change in the predicted wind resource affects the predicted energy yields, which directly influences cash flow and therefore, return on investment. There is the possibility that not enough energy is generated to cover costs or to satisfy energy demand during periods of high demand peaks (e.g. heatwaves or extremely-cold periods). In this sense, having accurate medium-range wind predictions is becoming increasingly important to anticipate the lack of balance between supply and demand. From the interactions with different users in the wind energy chain, it was identified that many can benefit from medium-range climate predictions. This is the case, for example, of operations and maintenance teams that need to schedule operations during the less windy periods, grid operators that need to know the amount of renewable energy that will go into the grid to schedule power plant operations, or financial teams that benefit from having a balance of the energy they can produce in the upcoming months to anticipate cash flow.

For users in the re/insurance sector, climate change adaptation in the medium-range involves adopting strategic decisions related to risks that are continuously changing when compared to the past. As climate change is predicted to increase the frequency and severity of extreme weather events, economic losses caused by natural catastrophes can also increase significantly (Botzen et al. 2010).

Table 1 Main challenges of three examples of climate services tailored to agriculture, energy and insurance and how they can help to adapt to climate change

Climate service	Description	Climate change adaptation	Challenges
Climate service for agriculture: *SECTEUR*	Participatory approach for user engagement to identify user requirements and decision-making (wine crop)	– Decision-making during the grapevine growth cycle – Grape trade in the market	– User engagement – Forecaster engagement – Tailor climate information to user's requirements – Communicate probabilistic information and prediction reliability – Make the tool attractive and usable – Sustain the tool's use in the long range
Climate service for energy: *Project Ukko*	Visualization tool for the wind energy sector	– Planning maintenance and operations – Energy trading – Estimation of budgets – Meet the balance between supply/demand	
Climate service for insurance: *Seasonal Hurricane Predictions*	Visualization platform of the seasonal hurricane activity for the re/insurance sector	– Catastrophe evaluation – Loss estimation – Pricing determination – Capital allocation determination – Claims team preparation and client warning	

The best strategy for re/insurers seems to be incorporating expected changes in probabilities of weather extremes in assessing exposure, pricing and risk management. Users from the re/insurance sector attending the SECTEUR workshop identified the assessment of risk exposure to be useful for catastrophe evaluation and losses estimation. Knowing the probability of occurrence of extreme events in the near future, re/insurance companies can determine pricing and restrict pay-outs through upper and lower limits (deductibles) of liability or by imposing restrictions and exceptions to insurance contracts. Climate predictions can also be useful to direct the allocation of capital towards situations where risks are more likely to occur, and can also be used for client warning or claims team preparation when an affectation is foreseen.

2.5 Challenges for Climate Change Adaptation

It is currently very difficult to get an overview of what medium-range climate predictions can do for all the sectors, possibly because climate services are evolving very quickly and many different actors are becoming progressively involved. Although this can be seen as a limitation to the use of climate predictions, it also creates challenges (Table 1). One of this challenges involves user engagement, ensuring an exchange of information about the user needs with the climate services research community in order to maximize the impact of what the large variety of available sources of climate information can offer to them.

Identified limitations can be divided between technical and those related to the user's perception of climate data. A technical barrier for the widespread use of climate services is that climate modelling resource capabilities are limited by the cost of the computational resources used to produce climate predictions, and so they tend to be semi-operational (not run continuously). The challenge of making these predictions operational involves user's interest in sustaining the tool in the long range. Limitations related to users perception may arise because the link between the use of medium-range climate predictions and adaptation to climate change is not always clear. Adaptation has been traditionally envisaged in the long-range, when climate projections have been undoubtedly considered useful tools, whereas climate change effects in the medium-range time scale are perceived to a lesser extent. The challenge here lies in clearly communicating these concepts to the potential users of climate services and in the generation of appropriate tools to support this communication.

The challenges to have fully-operational climate services that are actually used by users are many, and depend on the particular service and the familiarity of users with climate information. For example, user engagement is one of the challenges shared by the three climate services presented in this study. In this case, the climate service for re/insurance was the least demanding in terms of user engagement, since the re/insurance company was interested in the platform from the beginning, as both a way to gather useful information and as an additional tool to announce their

activities. Conversely, a higher engagement effort was directed to encourage forecasters to provide information on their hurricane predictions as a source of data for the climate service. In this case, the website was developed first, putting special attention in the visualization and design part, and it was eventually introduced to forecasters. From our experience, it really makes a difference when forecasters are faced with an operative tool rather than an idea of a platform-to-develop. A bigger effort, however, was needed to engage users in the wind energy sector. These users are generally familiar with weather and climate variability and see the potential of using medium-range climate predictions in their decision-making, but they tend to ignore how for simplicity. More efficient and targeted forms of engagement are needed to build trust in this sector, since prediction uncertainty is often seen as a barrier to the application of climate predictions (Otto et al. 2016; Taylor et al. 2015). The climate service for agriculture was the most demanding in terms of user engagement, since medium-range climate predictions are completely unfamiliar to this sector. For this reason, the presented climate service for agriculture focuses in user engagement for the framing and integration of user needs at early stages of the data product design. Integration of the user from the beginning is essential to avoid unrealistic expectations, but it also adds knowledge about which sources of uncertainty are the most relevant.

Tailoring climate information to user requirements is another challenge shared by the three climate services presented here. Tailoring encourages providers to recognize the differing information requirements of users and improves the bi-directional communication between users and providers. Tailoring information follows the same gradient as in the case of user engagement. Namely, the process was easier in the case of the re/insurance climate service, since the user was already aware of the type of climate information that best suited their needs. More interaction between users and providers was needed for the wind energy climate service, where sharing information and learning from each other was recognized as key for developing best practices. An important tailoring effort is also foreseen for the agriculture climate service, although this constitutes a next step after the current identification of users' needs.

Although not a straightforward topic, communicating probabilistic information and prediction reliability is necessary to apply climate predictions in climate change adaptation decision-making. In this sense, providers must ensure that both the probabilistic nature of predictions and its associated quality are adequately communicated and correctly interpreted by users. Because of the different expertise and previous knowledge in the selected sectors, this aspect is expected to go most smoothly in the case of the re/insurance climate service, whereas it might face more challenges in the agriculture sector. Users from the re/insurance sector are regularly dealing with risk information, meaning they are already familiar with probability and uncertainty concepts. Therefore, they are keener on incorporating probabilistic climate predictions to their decision-making. Users in the wind energy sector are also quite used to weather predictions (up to 2 weeks), but identify uncertainty as a barrier to incorporate medium-range climate predictions in their decision-making. Although the agriculture traditionally relies on meteorological data, users are rarely

aware of the usefulness of probabilistic climate information, or familiar with the concept of uncertainty. It is thus the job of the research community to communicate these concepts to the potential users of climate information. When communicating uncertainty it is particularly important to emphasize what we actually understand and to recognize that with improvements in the research, some uncertainty sources may reduce in the future.

In addition to the previously described challenges, making a tool that is attractive and usable is yet another issue. In this case, the climate services for re/insurance and energy are the two conceived as visualization tools. In both cases, visualization was important to raise awareness of the potential applications of medium-range predictions and to put probabilistic information into a usable form for decision-makers. This process required establishing a solid collaboration between experts from very different disciplines including design and art, since visually representing probabilistic information entails a compromise between scientific soundness, functionality and aesthetics (Christel et al. under review).

The last challenge, which is generally faced by climate services developed in a research environment, refers to the sustainability of the service in the long range. Namely, these tools are normally developed under the financial support of a particular project and, when the project ends, stakeholders' investment in the tool's maintenance is not guaranteed. Further investment largely depends on the successful development of climate models and tools that are actually incorporated in the regular decision-making of the climate-sensitive sectors. This requires increasing the quality and reliability of the predictions as well as the successful dissemination of the use of climate information among the different sectors.

3 Conclusions and Future Steps

The appropriate application of participatory approaches and graphical visualizations to communicate climate data is fundamental to the provision of climate services that can guide climate change adaptation decisions. Although climate services have been proven to be useful to inform decision-making of climate-sensitive sectors, their use is still not widespread. Limitations to more efficient development and more extensive use of climate services relate to user engagement, tailoring of climate information and communication of probabilistic information and prediction reliability.

In the first instance, it is necessary to understand the user's decision-making processes and ensure that the climate service will be suited to their needs. In fact, climate is often not the most important issue to users, and efforts should be rather directed to identify user's sensitivities, thresholds and risk tolerance related to climate and within their decision-making processes. Once the relevant processes are well understood, it is important to maintain a clear, consistent and regular communication with users. Additional work is needed to implement standardised options regarding accessibility and visual communication of climate predictions

towards the development of climate services. For instance, a clearer distinction should be made between climate projections and climate predictions, as end-users tend to assume that these two products show the same information. In addition, the common conception that medium-range climate forecasting is inaccurate and unreliable, makes user engagement challenging. It is therefore important to build a mutual understanding regarding the realistic scope of a climate service and the value that it could add to the sector. Application of economic incentives to demonstrate the added value of climate predictions is an approach that needs to be further explored. All these initiatives (standardization, use of economic incentives, etc.) are meant to facilitate the communication of the usefulness of climate information to the users. Although the users may differ, the challenges we face when trying to engage and understand the decision-making processes of any user affected by climate change are universal. The tools shown here can be replicated to many other sectors, such as water management, solar energy, health, etc., which are influenced by climate variability over medium-range timescales. To sum up, more effort needs to be directed to improve the aspects described here as well as to develop alternative ways of climate data visualization in order to make climate services operational, and therefore, sustainable in the long-range.

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Encouraging 10,000 Staff to Take Action on Sustainability: A Case Study of a Sustainability Engagement Programme in Higher Education

Lucy Millard

1 Introduction

The UK higher education sector has a significant impact on the environment through its teaching, research and operations. The sector has a total income of £30 billion and 14.3 million square metres of estate (AUDE 2016). The 20 Russell Group institutions in England, of which The University of Manchester is one, are responsible for around half the carbon emissions of the sector (Brite Green 2016). Universities have a responsibility to try to reduce this and, in the UK, have to report on various sustainability indicators.

This paper explores an environmental sustainability engagement programme that the largest single-site university in the UK, The University of Manchester has developed. The University of Manchester has 38,000 students, over 12,000 staff and an annual income of £1.01 billion. There are 245 buildings, 24 of which are listed, across 270 ha. The University has the largest student community in the UK and is one of the largest employers in Greater Manchester (The University of Manchester 2017a). The scale of the institution means that the environmental impacts, both positive and negative, are significant. Encouraging positive environmental behaviour at work can lead to a substantial reduction in environmental impact (Ruepert et al. 2016; Staddon et al. 2016) and the University decided to try to harness its large workforce to change environmental related behaviour.

The first-hand experience reflected on in this paper of developing, managing and delivering a large-scale innovative and ambitious engagement programme will provide others interested in organisational behaviour change and communicating climate change with ideas and methods to learn from.

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2 Social Responsibility At The University of Manchester

The University of Manchester is unique in British higher education for placing social responsibility as a core goal. It sits equally alongside the institution's commitments to world-class research and outstanding learning and student experience (The University of Manchester 2015a). The University's commitment to social responsibility addresses the fundamental question 'what are we good for?' The University describes social responsibility as 'the way we make a difference to the social and environmental wellbeing of our communities and wider society through our teaching, research and public events and activities' (The University of Manchester 2015b). The University has identified five social responsibility priorities:

- Research with impact.
- Socially-responsible graduates.
- Engaging our communities.
- Responsible processes.
- Environmental sustainability.

As most of the work that the University undertakes could come under the social responsibility banner, a small number of social responsibility signature programmes have been developed around each of these priorities. The signature programmes are outlined in Table 1.

10,000 Actions
This paper looks at the premise, process and outcomes of 10,000 Actions in more detail. Engagement with students on environmental sustainability is delivered through the Ethical Grand Challenges programme and the University wanted to deliver similar engagement to its staff. Alongside this, Manchester City Council published a climate change strategy for the city of Manchester, *Manchester: A Certain Future* (Manchester City Council 2013) that included an aspiration that every person who lives, studies or works in Manchester should receive training in

Table 1 Social responsibility signature programmes at The University of Manchester

Addressing inequalities in Greater Manchester The University's research that address society's most pressing issues of fairness	**Ethical Grand Challenges** Every undergraduate is provided with the opportunity to confront key challenges: sustainability, social justice and workplace ethics	**School Governor Initiative** Contributing to the leadership of state schools in creating the largest growth of School Governors in the UK
Cultural Explorers Transforming the learning experiences of primary schools by opening up the cultural institutions of the University	**The Works** An employment initiative providing support to job-seekers and job matching to local employers including the University	**10,000 Actions** Providing the opportunity to every member of staff to engage in a programme of positive action on sustainability

carbon literacy to enable the city to move to a low carbon future. With a population of over 10,000 staff, The University of Manchester would have to play a significant role in this ambition and this is where the concept of 10,000 Actions began.

3 Rationale

The rationale behind this paper, and 10,000 Actions, is that as a large organisation with a significant number of employees, The University of Manchester had an opportunity to communicate the issues of climate change and its impact to its staff to lead to a change in behaviour, thus reducing its environmental impact. Core to 10,000 Actions is a set of videos that explain climate change, sharing the University's research in this area in an accessible way. These are publically available[1] and so is a resource for anyone who wants to communicate climate change. A unique communication channel to have these conversations has been opened at the University, including prompts for action and two-way feedback. This paper provides a case study of how one organisation approached communicating climate change to a wide and diverse audience, a model that other institutions could potentially adopt and adapt.

4 Premise

When deciding on how best to communicate climate change, The University of Manchester looked at existing methods, one of them being The Carbon Literacy Trust. As The University of Manchester is a large and very diverse institution which exists to generate knowledge and educate people, it was decided that an off the shelf product would not be the best way to engage employees. A group, comprising of a mix of academic and support staff, was established to decide on the best way forward for the University. The following principals were decided:

- The use of language when communicating climate change needs to be explored carefully.
- The potential to educate staff is very important.
- An opportunity to showcase the University's own research and knowledge.
- Needs to be delivered online where possible due to the numbers. An offline version needs to be developed for staff who do not have access to a computer.
- The process and delivery should be as environmentally friendly as possible as well as using local suppliers.
- It should meet the city of Manchester's objectives as well as the University's.
- Data collection and monitoring to be built in.

[1] www.youtube.com/channel/UCiONsNvprJGR4CSkPvAni0A.

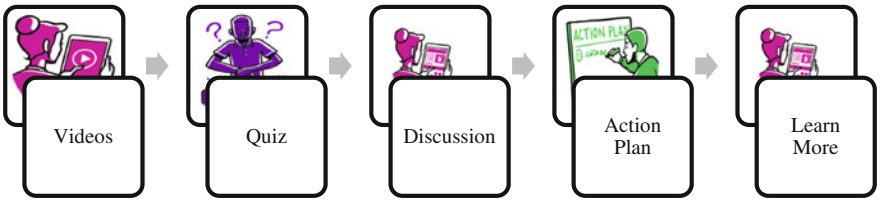

Fig. 1 10,000 Actions learning process

- Feature different types of staff so people could identify with others.
- Senior management and HR buy-in is required.
- The programme should be about learning and taking action.

After some months of discussions, consultations and testing different approaches the concept of a learning and engagement programme called 10,000 Actions was agreed. Figure 1 illustrates the learning process of 10,000 Actions.

5 The 10,000 Actions Online Process

When a user first logs into 10,000 Actions they are presented with an introductory video which explains the programme and why it is important using the concept of systems thinking to explain climate change. A local artist[2] was commissioned to draw the outcomes of a meeting of leading experts on systems thinking from the University (Fig. 2). This is the basis of 10,000 Actions and forms the branding of the programme.

Users then watch a series of videos on six sustainability themes in more detail:

- The living campus.
- Responsible purchasing.
- Waste.
- Energy.
- Water.
- Travel.

All of the videos feature world-leading academic experts on the subject from the institution as well as professional support staff who are responsible for that area operationally. Each video ends with a series of a wide-range of staff saying what action they take in that area, for example "I drive an electric car to work".

Every video is followed by a quiz, a discussion board and a 'learn more' section which explores the issues further with links to journal articles, news reports and videos. This learning section is followed by an action planning process. Software

[2] www.thehammo.com.

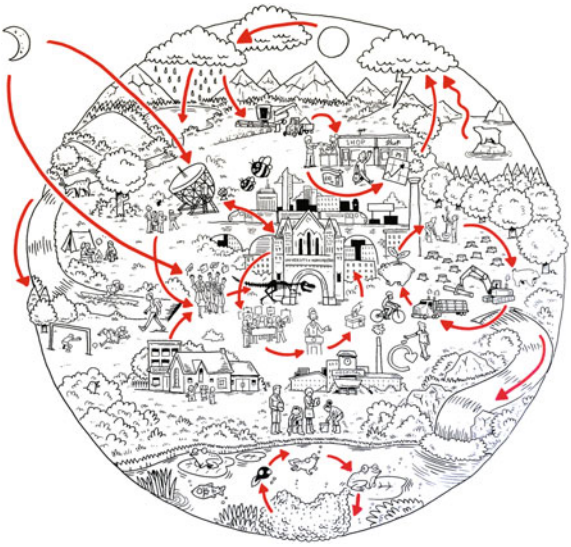

Fig. 2 Systems thinking diagram

has been developed to provide an action planning tool which profiles what type of member of staff the user is through a series of demographic questions. It then provides a list of issues in the six themes which users select and then rank in order of importance to them. The option to add their own issues is also provided. Finally, the learner is presented with a list of actions that they can take as a member of staff at The University of Manchester: an individual action plan. There is an option to delete an action, mark it as 'not started', 'in process' or 'completed' as well as add evidence and add their own action.

6 The 10,000 Actions Offline Process

Around 1000 (10%) of staff at the University do not have access to a computer at work and so a separate offline process was developed for:

- Cleaners and porters.
- Maintenance.
- Landscaping.
- Catering.

Some of the actions provided in the online tool would not be relevant, for example, these groups of staff do not buy any goods or services so the responsible purchasing section was taken out. Actions that were relevant to these roles were added such as 'before requesting new uniform, think about whether it needs replacing as often'. The supervisors of these staff said levels of English, reading and writing would need to be taken into consideration. Due to these factors, a series of

Fig. 3 Example of an action flashcard

flash cards (Fig. 3) and a simple checklist were developed as an offline version of the action planning tool.

Staff in these roles were timetabled off their rota for an hour to attend a session. This started with watching the 10,000 Actions videos, meaning that all 10,000 staff across the University had access to the same learning. Originally it was planned to then use the flashcards that had been developed in small, facilitated groups for discussion. The session would conclude with staff filling in their paper-based action plan individually. After the first two days (eight sessions) of running these, we did not feel that the staff were engaging well with them. Therefore we tried to offer questions where attendees could raise their hands to indicate preference. For example, after watching the travel video, asking who drove to work, who walked to work. This generated some discussion, which the facilitators then used to drive further debate. Examples of questions used include:

- How do you use water at work?
- When you empty recycling bins do you find that people have used them correctly?

Running the sessions in this way seemed to provoke more debate and engagement. The hour concluded with creating a simple, individual action plan, the results of which can be seen in Tables 7, 8.

7 Results

In the first two months of 10,000 Actions being live, 941 action plans had been created through the online tool and 351 through face-to-face sessions. 174 (18.5%) of the online users were academics and 767 (81.5%) in professional support services, library or cultural institutions. As all offline users were non-academics, in total this makes 13.5% academics and 86.5% non-academic out of 1292 action plans.

The online tool asks a series of demographic questions. These profile the user and then only offer actions that are relevant to that job type. For example, someone who indicates that they do not work in a laboratory would not be given an action related to fume cupboard control. Additionally, this data gives an indication of the type of job roles that are engaging, and not engaging, with sustainability. Table 2 lists the demographic questions asked and the responses.

The issues and actions presented in the action-planning tool are grouped by the six themes of 10,000 Actions. Water and living campus were merged in this instance, as the actions that people can take at work in these two areas are limited. An engagement theme was added, as there are a lot of crosscutting themes, such as

Table 2 Demographic questions and responses

Response	Number of users
Do you have a Laboratory-based role or does your job involve laboratories?	
Yes, in a teaching laboratory	14
Yes, in a research laboratory	58
Yes, split between a teaching and a research laboratory	31
No, my job does not involve laboratories	838
Do you have a student-facing role or come into contact with students?	
Yes, a significant proportion of my role is working directly with students	235
Yes, a small proportion of my role brings me into contact with students	370
My role does not bring me into direct contact with students	336
Do you fly or book flights for business travel?	
Yes, I fly on university business	122
Yes, I book flights	81
Yes, I book flights and I fly on university business	95
No, I do not fly or book flights on university business	643
Are you a budget holder?	
Yes, I manage budgets on behalf of The University	224
No, I do not manage budgets on behalf of The University	717
Are you involved in the process of buying goods or services on behalf of The University?	
Yes, I make requests for goods and/or services	317
Yes, I order goods and/or services	220
No, I am not involved in these processes	404
Do you develop plans, policies or strategies?	
Yes, I manage	98
Yes, I lead	93
Yes, I advise, support or input	302
No, I do not develop plans, policies or strategies	448
Do you manage staff?	
Yes, I manage a small team (0–10 FTE)	252
Yes, I manage a team (10+)	106
No, I do not manage a team	583

Table 3 Theme groupings

Theme	Average selection rate (%)	Total issues selected
Responsible purchasing	54	1270
Engagement	41	1221
Energy	37	1114
Waste	35	1070
The living campus and water	35	1055
Travel	25	1057

embedding sustainability in teaching, which did not clearly identify with one particular theme. Table 3 shows selection rates and the number of issues selected across each of the theme groups contained within the tool.

Responsible purchasing was selected at more than twice the rate that travel was. The University of Manchester has invested a lot of time in promoting sustainable travel initiatives. The low selection rate for travel could indicate that this focus has had an impact, staff travel sustainably where they can and therefore they do not perceive it as an issue anymore. Or it could be that users have selected issues that they have not heard so much about and so are perceived as new and of interest.

Under each theme, users were presented with a set of pre-defined issues. Table 4 shows the top five issues selected and the bottom five issues selected.

This data is powerful for institutional strategy setting. The issue with the highest selection rate (69%) is 'environmental sustainability should be embedded into everyday management and strategy processes'. Social responsibility, including environmental sustainability, is one of the three core goals of the University and this response shows that this is recognised by staff. The issues that are selected the least are the more negative ones, indicating that people do think about their resource use.

Users are provided with the opportunity to add their own custom issues. Examples of some issues added include:

- I have been introducing the concept of green campuses in low income countries.
- I work with companies and consider the environmental stance of these before I enter into partnership.
- I boil less water.

The issues added here show the different levels of understanding and action on environmental sustainability amongst this group of staff. Simple issues such as the amount of water used to assessing the environmental stance of companies before working with them and introducing the concept of sustainability into other countries. This also demonstrates the impact that higher education can have globally as well as internally at an institutional level.

Table 4 Top and bottom five pre-defined issues selection rate

Issue	Theme	Selected	Presented	Selection rate (%)
Sustainability should be embedded into management and strategy processes	Engagement	259	375	69
I do recycle but there is probably more I could do	Waste	682	1005	68
I care about where the things we use come from	Responsible purchasing	635	1004	63
I don't make enough use of the green spaces on campus	The living campus and water	564	1004	56
I order things for myself	Responsible purchasing	125	230	54
My job involves travelling	Travel	229	1004	23
I don't really think about my water usage	The living campus and water	212	1005	21
I could do more to save energy	Energy	187	1004	19
I don't really think about where my waste ends up	Waste	75	1005	7
I have responsibility for purchasing University-owned vehicles	Travel	5	230	2

When presented with an action, users are provided with several options for each one:

- Not started
- In progress
- Completed
- Add evidence
- Delete

Tables 5, 6, and 7 show the kind of data that providing these options generates.

Table 5 lists the top five completed actions across online users. These are simple actions and provide a baseline of what actions staff were already taking on environmental sustainability before taking part in 10,000 Actions. Additionally, they are all actions that had already been embedded within the institution for a number of years. When writing and developing the content for the online tool, it was decided to include simple actions that most staff already did to encourage staff to feel like they were already contributing as well as demonstrating that more could be done.

Table 6 shows actions that users have not yet started and did not delete from their action plan, indicating that they were interested in them and were likely to do start doing them. It is interesting to note that the majority of them relate to food and the heritage of the University, something that is of popular national and local interest and often appears in the news.

Table 5 Top five completed actions

Action	Appeared[a]	Deleted	Not started	In progress	Completed	With evidence
Use a reusable water bottle	685	18	441	53	173	50
Sign-up to the social responsibility newsletter	323	8	197	14	104	37
Visit Whitworth Park	569	17	447	30	75	17
Walk to meetings	231	7	132	25	67	20
Choose ethically sourced products	640	25	498	64	53	25

[a]Actions are presented as an option a user could choose depending on their responses to the demographic questions and issues. This means that staff are not presented with all the possible actions in the tool. The rate that they are offered is the "appeared" data

Table 6 Top five not started actions

Action	In progress	Completed	Not started	Appeared	With evidence	Deleted
Ensure equipment has correct end of life disposal	33	33	557	685	15	62
Choose actions from our food guide	35	32	533	640	14	40
Choose ethically sourced products	64	53	498	640	25	25
Make some time to explore nature as part of your working day	53	22	464	569	14	30
Take a heritage tour to find out more about the University's history	13	29	459	569	9	68

Table 7 Top five deleted actions

Action	In progress	Completed	Not started	Appeared	With evidence	Deleted
Take outdoor fitness classes at the Whitworth	2	4	438	569	0	125
Use our biodiversity app to record sightings	9	2	456	569	2	102
Join a lunchtime walk	18	16	441	569	10	94
Visit the arboretum at Jodrell Bank	8	38	439	569	8	84
Take a heritage tour to find out more about the University's history	13	29	459	569	9	68

The top five deleted actions shown in Table 7 are all under the living campus theme and all involve some form of exercise. The University of Manchester is a very urban campus and undergoing a significant period of change with a £1 billion masterplan (The University of Manchester 2017b). Some staff may feel that the campus currently resembles more of a building site rather than a haven of biodiversity to be enjoyed. The city of Manchester is also currently doing extensive transport infrastructure work (Manchester City Council 2017) on the main routes to and through the University which also contributes to the construction site feel. Despite the actions presented being the top five deleted, they have also been chosen a number of times by users so have appeal to some.

8 Non-computer Sessions

During one week in December 2016, 21 face-to-face sessions were held for Estates and Facilities staff that do not have access to a computer at work. 351 people attended these sessions and made their own action plan using a simple paper-based checklist. Staff were presented with a table of actions with two columns: "I already do this" and "I'm going to do this". They were asked to ignore actions that were not relevant or did not interest them. Table 8 shows the top five actions that staff already do and Table 9 shows the top five actions that staff said that they would do in the future.

Three of these top five actions were bespoke to this staff group, which is to be expected for actions already undertaken.

One of the main discussion points across these sessions was related to the fact that these staff work very hard to maintain the building but they normally only work in one building and do not know much else about the rest of the campus. This led to great interest in the heritage tours, which many of the attendees did not realise existed.

Table 8 Top five "I already do this" actions from non-computer sessions

Action	Number of times selected
Before requesting new uniform, think about whether it needs replacing as often	175
Use a reusable water bottle	166
Look after equipment so it doesn't need replacing as often	165
Recycle green waste	157
Find out where appropriate recycling facilities are and use them	141

Table 9 Top five "I'm going to do this actions" from non-computer sessions

Action	Number of times selected
Take a heritage tour to find out more about the University's history	77
Visit Whitworth Park and Whitworth Art Gallery gardens	74
Come up with at least three different ways you can save water	61
Visit the arboretum at Jodrell Bank	55
Sign-up to the sustainability series	55

9 Discussion

10,000 Actions is a significant programe for The University of Manchester and the higher education sector. It is the most ambitious staff project for sustainability in the sector as well as the most ambitious learning and engagement programme for the University. This paper analyses the first two months of the programme where a lot has already been learned and a number of issues have been raised.

The online tool provides a lot of data but it is difficult to make conclusive statements without looking at it alongside other data and without more research. For example, it is indicated that users are least interested in travel. The University has collected data on different forms of travel for a number of years so looking at those trends alongside the data from 10,000 Actions may give a more complete picture. Interviews could be undertaken with users to delve further into responses and opinions given. Currently, 13% of staff across the University have made an action plan. As this increases, more data will be provided which will help give a more robust data set.

Improvements in the software would also give better data. Currently data is not provided by date so it is not possible to see if an intervention has resulted in an increase in action. There are other ways we can see this, for example, an article written on the intranet concerning applying for a carbon literacy certificate saw a spike in applications. This is not possible across all actions however. It is not possible to view how many actions have been taken by specific faculties, schools or directorates; it is only possible to see how many action plans have been made. This has limited the messages on completion rates. The way the software was designed means that parts of the action planning tool have to be written in a certain way which is normally negative, especially at an issue level. This phrasing is likely to affect the way a user engages with an issue or action and therefore may influence an outcome.

When 10,000 Actions was launched a considerable amount of effort was made to encourage staff to take part. Work now needs to start on encouraging staff to log back in and update their action plan so we can see if data has moved from 'not started' to 'in progress' or 'completed'.

It is clear that the data generated by the online portal has its limitations. Through the face-to-face sessions that 351 people attended, we have collected some more

nuanced information which highlighted some processes that could be improved for the future. The whole premise behind 10,000 Actions is what you can do at work. Some of the learning and actions are applicable to your home life but it was decided to focus just on work. However, when the issues were discussed amongst this group of people, they kept on drifting back to their home life. One of the reasons we decided to focus on work and not home life was the feeling that some people may not take kindly being told how to behave and act outside of work. Interestingly, this did not happen amongst this group of staff.

The paper-based action plans were designed to be a simple checklist so just had two columns: "I already do this" and "I'm going to do this". This simplification resulted in confusion as a number of people thought that they had to tick every column, which could potentially skew the data. Where this occurred, we did not include the actions in the total. To solve this problem a third "I'm not going to do this" column could be added in future. A lot of actions were provided on the checklist which were technically applicable to these staff but in reality the majority were not going to engage with. In future, it would be better to remove these and have fewer actions but more relevant ones.

Through these 21 sessions it is obvious that people are the eyes and the ears of the campus. They start their working day early so can see what equipment is left on. They empty the recycling bins so can see levels of contamination. When asked if they reported issues such as leaking taps, 100% of attendees said that they did. Their biggest gripe though was that despite playing such an important role in sustainability, they found it hard to be listened to and the majority of them as a result were becoming disengaged and the phrase "but I'm just a cleaner" was heard repeatedly. Following these observations, plans are being made to work with management to start to develop ways to ensure that they feel listened to. Another issue was that most of the information provided about sustainability issues is done online. We have created a noticeboard in one building to try and provide information but The University of Manchester has over 300 buildings so this is not a sustainable solution to the problem.

The data and feedback that has been provided through this engagement activity has started to inform institutional strategy. The University of Manchester is currently drafting two new plans: a Sustainable Resources Plan and a Living Campus Plan. The findings from 10,000 Actions so far is steering the direction of those, for example, the need to do specific campaigns on waste and energy, and 10,000 Actions is now ideally placed to deliver the messages required to meet the objectives in these plans.

It is possible to see that people who have taken part in 10,000 Actions have already taken some action. Numbers signing up to relevant newsletters and attending sustainability seminars have increased as well as the numbers of people contacting the institution's Environmental Sustainability Team. Staff have been sharing their actions on social media and one of the University's suppliers has also taken action on sustainability in the spirit of 10,000 Actions.

It is important to note that the data presented in this paper is from the users who have created an action plan, the end stage of 10,000 Actions. Many more have

taken part, which can be seen through Google Analytics and the numbers of views on YouTube where the videos are hosted. 10,000 Actions has appeared on all communications channels at the University and appeared as agenda items in all areas of the organisation. There are high levels of awareness of the programme and what it means. Even if people have not made their own action plan, they are talking about sustainability and know that The University of Manchester is committed to this area. 10,000 Actions has been accredited by The Carbon Literacy Trust and was the first university in the world to achieve a carbon literate organisation award (The University of Manchester 2016).

10 Limitations

This paper has been written after implementation of the project but only two months on in the data collection period. This results in some constraints to the work. The research presented is from data collected from the online tool and from 21 face-to-face sessions that were held. Further research will be undertaken in the future on whether this communication on climate change has led to an understanding of the issues and resulted in behaviour change. Before the next face-to-face sessions are held, questionnaires will be circulated to attendees on their attitudes and behaviours. Post intervention, the questionnaire will be repeated to measure the effects of taking part in 10,000 Actions. Focus groups are also being arranged to understand why people have, or have not, taken part in the programme and what impact it has had.

11 Conclusion

Through this case study we have seen the issues and challenges in attempting to communicate climate change with over 10,000 staff simultaneously to lead to a change in behaviour. These issues were overcome in developing innovative online and offline methods to engage with a wide-range of staff. This case study outlines one approach at one institution and suggests how this approach can be developed and improved in the future. This paper demonstrates it is possible to achieve institutional wide engagement on sustainability through climate change communications to achieve changes in behaviour.

The work presented in this paper describes some of the lessons learned attempting to communicate climate change on a mass scale at a large university. Using the organisation's own staff and research to communicate the messages instead of buying a generic system that already existed has been vital in encouraging staff to take part in 10,000 Actions. The communications messages to engage users were centred on this opportunity to see their own colleagues and what they are doing for environmental sustainability.

The biggest success in this approach to communicating climate change was the dual approach of learning about the issues and then being given a simple way to generate a personalised action plan so that users could take action. This approach sets 10,000 Actions apart from other methods of environmental sustainability engagement and has already resulted in changes in behaviour. Continued communications are required to encourage this behaviour and prompt users to revisit their action plan and inform the University of what actions they have taken.

Research undertaken on the data provided after the first two months is already showing interesting results as described in this paper. More information is needed, and from different sources, to make robust conclusions about people's behaviour regarding sustainability in the workplace. Future prospects for this include questionnaires pre and post interventions, focus groups and interviews. Improvements in the software behind 10,000 Actions will also result in more nuanced data. Additionally, there is an opportunity to improve the face-to-face sessions. Work so far has shown that it is easier, and more effective, to engage staff using the online platform so this should be the first preference wherever possible.

10,000 Actions has engaged a significant number of employees at The University of Manchester with environmental sustainability. Beyond sustainability, the project has given every member of staff, no matter what their level of education, access to knowledge from world-leading experts and the opportunity to play their part in tackling one of the world's greatest challenges. Most importantly, the actions that are being taken demonstrate the crucial role that higher education has in moving towards environmental sustainability. 10,000 Actions showcases how that can, and is, being achieved not only on the University's doorstep but also globally through the impact that our academic research has.

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Disseminating Climate Change: The Role of Museums in Activating the Global Public

Morien Rees and Walter Leal Filho

1 Introduction

Over the past 25 years, the Intergovernmental Panel on Climate Change (IPCC) has published five assessment reports documenting the expanding scientific knowledge base of climate change and has been providing the world with an objective view of its political and economic impacts. The reports, the most recent of which was the 5th Assessment Report, commonly known as AR5, have included a summary for policy-makers to enable governments to implement the necessary measures (IPCC 2014). A version has also been summarized for the press and other media to facilitate communication of the challenges to the public (IPCC 2014). This process culminated in 2015 with the diplomatic triumph of the signing of the Paris convention. Its goal is to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.

Since Paris, leading members of the scientific community have been casting grave doubts on the achievability of these goals (Simms 2017). Professor Emeritus Bill McGuire gives the possibility of achieving two degrees "a cats chance in hell", (Simms 2017) while the pursuit of the 1.5° will probably be history before the convention comes into force in 2020 (Mercator Research Institute on Global Commons and Climate Change 2017).

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Thus despite the causes and impacts being known to both governments and their electorates, the former are either unable or unwilling to implement the necessary measures, whilst the latter, in the main, show inertia in the face of the growing body of knowledge available to them through the press, media and the ever increasing number of sites dedicated to the subject to be found on the web.

Bookended by Professor Kevin Andersen's 10% (Manchester Climate Monthly 2017) who by changing their lifestyles could enable the immediate crisis to be surmounted and the forty per cent of the world´s population who haven't heard of global warming (Martin 2015), the remaining fifty per cent include those described by Michael Hoexter's (2016) soft climate denial theory, a particularly pernicious, although compelling, view of inertia. While accepting the realities of climate change impacts they only support measures that are wholly inappropriate to the scale of the challenge posed by global warming. Soft climate denial leads "… often to hand-wringing or other ineffectual actions but no decisive steps taken towards meeting the challenge of human-caused and human-accelerated global warming … and may be functioning as a "face-saving" device to mask fundamental inertia" (Hoexter 2016). In his opinion individuals are not capable of breaking out of soft climate denial alone but "… must work together … to transform government climate policy" (Hoexter 2016).

There is indeed broad agreement that the task of ensuring that governments undertake the measures needed to mitigate the impacts of global warming today and in the future is reliant on the active participation of the global public. Hoesung Lee, the current chair of IPCC states: "Ultimately [though] tackling climate change is a global problem, so individuals should encourage their governments to take action" (quoted in Rice-Oxley et al. 2017). However, it is clear that to achieve this political goal, it will be necessary to galvanize the public to a totally different degree than has been the case over these last 25 years. This in turn suggests that the means of communicating the nature and challenges of climate change are also in need of urgent review (Leal Filho 2009). There is a need to question whether the forms and channels used to communicate these challenges have been adequate.

Much has been written about the need to better communicate matters related to climate change (e.g. Leal Filho et al. 2007). Talks presented at professional academic meetings may be clear, concise and to the point, but when scientists talk to scientists the language is often impenetrable for the layman. Likewise, their means of communicating ideas can seem intimidating, often overestimating the ability of the public to understand even relatively simple graphic presentation. And while the IPCC reports have been summarized for the press and other media to facilitate communication of their contents to the public, there is a growing belief that neither the means of communication nor the facts in themselves, can overcome the public's present state of inertia (Gardiner 2011). If this is true, then scientists and disseminators are at present like the orchestra playing bravely on as the Titanic approaches the iceberg.

2 Communicating Climate Issues: The Role of Museums

One institution that is often overseen in discussions on climate change communication is the museum. Museums are known to be excellent places where learning experiences are facilitated by a combination of visualisation and first-hand experiences. Their collections offer, on many occasions, very good opportunity to communicate and foster learning on climate change. Museums, as Robert Janes, the Editor-in-Chief of Museum Management and Curatorship and author of *Museums in a Troubled World* (2009), writes "… are key intellectual and civic resources that are largely untapped and unacknowledged" (Janes 2015: p. 5). Unfortunately, this sector's potential has not been realised as it could or indeed should be.

This paper proposes that museums have a role to play, both as sites for communication and through their dissemination skills. It will examine the proposition that, in the process of overcoming inertia and activating the public, *where* communication takes place and *how* it is achieved is of equally importance to *what* is communicated.

Museums as institutions have a number of characteristics, individually and collectively, that enable them to offer a unique possibility of disseminating both the international nature of global warming and the local impacts of climate change. One of the greatest challenges in activating the public worldwide is to make clear the relationship between the global and the local. The Janus-like[1] quality of the museum—both a member of a global institution while at the same time often functioning as a focal point in local communities—offers a site for communication, a bridge, where local impacts can be located in the wider context of a global story.

Storytelling has increasingly been recognized as an effective interpretative tool within museums and galleries. Varanger museum, located in Northeast Norway, has had some success with storytelling as a dissemination tool. At the Steilneset Memorial, contemporary human rights are addressed through story of Gundelle Olsdatter. Fifteen year old she was accused, tried, condemned and burnt at the stake in the 17 century witch trials. The goal of the city development project Vardø Restored[2] and the Coma Festival of street art was to wake the community in present day Vardø from the coma induced by effects of the restructuring of the global fishing industry at the end of the twentieth century. In both cases storytelling served as a bridge, a means of revealing relationships that otherwise might be overlooked. In the former drawing attention to the enduring mechanisms that result in minorities who stray from establish norms becoming victims of sanctions by the majority, whether in witch trials in 1662 in Arctic Norway, in the history of discrimination against the LGBT community, or indeed bullying in the 7th grade. While Vardø Restored's focus on global restructuring, through among other things an international art project, became a means of activating the local community in the face of depopulation.

[1]Janus was the Roman god of passages, bridges and transitions.

[2]See www.vardorestored.com.

In a discussion with the writer Susan Sontag about the (lost) art of storytelling, the late John Berger one of the foremost storytellers of the last fifty years, implies that storytelling in itself can be Janus-like (Berger and Sontag 1983). The storyteller is both at the centre of the story but also at a distance from it. The most successful stories, while addressing the particular reveal universal truths. The gift of the successful storyteller is to allow the particular in the story to be understood universally: what is being narrated locally coexists within a much wider context. "Story telling is a struggle to give meaning to experience… it is continually comparing like with unlike, what is small with what is large, what is near with what is distant… the act of approaching a given moment of experience involves both scrutiny (closeness) and the capacity to connect (distance)" (Berger 2016: p. 62). The role of storytelling seems to have experienced something of a renaissance in recent years—possibly as a reaction against and a response to the ever-growing prevalence of the screen as a means of communication, and not just in museums. Significantly, storytelling has also been increasingly seen to be a model whereby one can engage communities at a local level in the goal of activating the public.

Storytelling in the context of communicating climates change can take a number of forms: inspiring narratives of how communities tackle the impacts of climate change for example the Marshall Islanders in the Pacific, or as Per Espen Stoknes the author of *What We Think about When We Try Not to Think About Global Warming* (2015) maintains,

> … stories can give directions and also make us sense that others are with me on this. Stories create community … individually people feel helpless, but by becoming a part of a story, a positive narrative about the future that is community based, the individual becomes empowered (Stoknes 2016).

John Berger is adamant that in the very idea of a story there is something to do with shelter, the story itself representing a kind of habitation or home for the community who are listening. (Berger and Sontag 1983).

Stoknes (2016) suggests that we should develop positive narratives in climate change communication when cultivating empowerment, citing four: smart green growth, well being and health, humanity's role in relation to religion, nature and ethics and a move from domination of nature to stewardship and re-wilding. George Marshall the author of *Don't Even Think About It: Why Our Brains are Wired to Ignore Climate Change* proposes a heroic quest narrative (Marshall 2014: p. 234) and echoing both the positive and communal approaches suggests successful narratives are those "… based on cooperation, mutual interests and our common humanity" (2014).

In approaching communicating climate change Mika Hietanen, associate professor in rhetoric at Uppsala University emphasizes the importance of trust–ethos, credibility (Hietinen 2016). Most of all we trust those messages coming from our own surroundings, from people close to us. When it comes to making our minds up we trust the values held by people close to us. Research confirms that climate change communication is especially successful where "… analogies are used where climate change phenomena are compared to other processes that the participants

were familiar with and could relate to and could understand more easily" (Hietanen 2016). Similarly, that in the task of influencing the public, the biggest effect is achieved through small group deliberations. This is echoed by the realization of climate campaigners such as 350.org, that one should build an organization around small groups. As Alex Evens writes in *The Myth Gap* (2017):

> The Jubilee 2000 debt-relief movement understood it… and built its campaign largely from church congregations. The Obama '08 campaign won using a ground operation based on small groups, and we are seeing climate activists… whether in fossil fuel divestment… rooted in college groups… or the small group tactics that underpin the mass actions like shutting down production at the Ene Gelände coal mine in Germany (p. 13)

Heitanen like Stoknes maintains that the greatest challenge for politics in general is how to engage citizens at the grassroot level, in their own neighbourhoods, in their daily lives (Heitanen 2016). He concludes that where this is achieved, change happens. Here we are in the realm of local museums that can act: "as social spaces, arenas in which different communities can come together to understand the challenges of climate change through dialogue, share ideas for action and build networks that support responses" (Janes 2015: p. 5). Experiencing Professor Emeritus Hooper Greenhill's vision of the museum as "… a process or an experience" rather than a mere building, one which "… moves as a set of processes into the spaces, the concerns and the ambitions of communities" (quoted in Salazar 2011: p. 130).

Salazar proposes that "… museums … can act as change-agents in fostering a new form of public pedagogy that incorporates differing civic epistemologies around climate change education and action" (2011: p. 123). He argues that local museums by prioritizing communication over information can lead to increased agency, and position these institutions in connection to local communities and NGOs. "Museums ought to move beyond … informing visitors (the vertical flow of messages) to engage with communicating … (a horizontal process of dialogue and particpation)" (Salazar 2011: p. 124). It is through this process of participation that local communities can be activated.

Amplifying Stoknes' juxtaposition of communication and storytelling he states that climate change is a story based on experience, it is not just disembodied information without storytellers. And a storyteller cannot tell a story without listeners. He sees the role of the museum as "… creating intersubjective spaces of communication and association to interest the public in the public interest*"* (Salazar 2011: p. 128) where the basis for engaging climate change is not information but conversation and the cultivation of a culture of communication: the museums as a home for community storytelling—and listening.

Thus it would seem that museums at a local level, offer an arena that can accommodate and nurture the community based activism that many see as the future hope in the urgent political process of implementing the necessary measures to combat the worst impacts of global warming.

However, there is also a need for a profound change in the model of how the global challenges of climate change are communicated to the public. Despite a few notable exceptions, for example the Guardian's recent "Global Warning: 24 h on

the climate change frontline as Trump becomes president" (Rice-Oxley et al. 2017), the media based channels that have been the conduit for transferring this knowledge to the public, have only succeeded at best in"… disseminating recycled scientific information to passive audiences rather than communicating the complexities of climate change, let alone engaging their public with possible climate change action" (Salazar 2011: p. 124). At worst, they have been harbingers of doom.

Museums at a local level then can be seen to offer sites and strategies for achieving this change in communication models but also on the international stage, they are in possession of tools to facilitate the development of a new model for the communication of the global perspective.

Museums are perceived by the public as being impartial actors in society and guardians of truth. They transcend boundaries in both space and time, establishing successful patterns of international cooperation over national borders. According to Wikipedia (2017) there are 55,000 museums in 202 countries. In essence, there already exists an infrastructure that could be used for communicating the global nature of the challenges and impacts of climate change. In December 2016 the executive board of the International Council of Museums initiated an extensive review of various climate change initiatives.

Museums also erase borders between disciplines, and between other sectors of society, a precondition for addressing the complex nature of climate change as a cultural, ecological and technological challenge. Museums are equipped with tools for the dissemination of complex themes and have the capacity to rethink and adjust their dissemination skill sets to meet new challenges. Thus they are capable of building awareness, changing attitudes to climate change and activating the public on a global scale.

Marcus Carson, a Senior Research Fellow at Stockholm Environment Institute, maintains that to succeed in climate change communication one must "think globally, act locally". (Carson 2016) Museums are emerging as institutions that are able to bridge the communication gap between the global and local.

One example of the latter is being developed by Varanger museum. Situated on Norway's northeast coast, it is located in the sole municipality on mainland Norway within the arctic climatic zone. The arctic tundra will be more challenged by climate change than any other terrestrial biome. This has inspired a museum project on how climate change is impacting Varanger Peninsula National Park.[3] The museum—and it is difficult to envisage any other institution being capable of pulling this off—is assembling an interdisciplinary constellation: climate researchers from Norway's Arctic University in Tromsø,[4] national park researchers and rangers, NGOs, philosophers and the local inhabitants of the park. The goal is to provide an arena that encourages an awareness of the ethical nature at the heart of global warming by presenting the local impacts of climate change through dialogue and experience of

[3] http://www.miljodirektoratet.no/Global/dokumenter/Publikasjoner/Brosjyrer/Varangerhalvøya_NP_E_nett%20181011.pdf.

[4] www.coat.no.

nature as visitors wander through the national park's landscape. This museum's arena has no walls; in this project it is a conceptual space—reminiscent of Greenhill's aforementioned vision for the museum—that hopefully will be experienced with wonder as our visitors wander through national park's landscape. The concept of an arena that is being proposing here, focusing on the local impacts of climate change within a global framework, can encompass many dissemination approaches, target groups, sites and constellations: local/global, analogue/digital.

The methodology being developing for the pilot project combines conversations, led by philosophers, with practical research-based assignments. By the summer of 2017 it will have investigated the impact of climate change on bumblebees—building nests and monitoring the numbers of the four species known to be found in the Norwegian Arctic. It will be followed by modules on the arctic fox, salmon smolts and migrating birds.

The project draws on the recent work of two moral philosophers, Professor Stephan Gardiner (2011) and Professor Arne Johan Vetlesen (2015), together with the work of Dr. Juan Salazar, they have provided four insights that are at the heart of this local project: The first is that the greatest challenge presented by climate change is ethical. What matters most is what we do to protect those vulnerable to our actions and unable to hold us accountable, the global poor, future generations and non-human nature. Secondly that facts are not enough to change attitudes to climate change or when considering our behaviour towards nature. Thirdly there is a difference between information about, and the communication of the challenges of climate change. And finally the only thing that can change our behaviour is that we rediscover that nature has a value in itself, through experiencing it.

3 Conclusions: Activating the Global Public

Although the Arctic is likely to be challenged greatly by global warming, the impacts of climate change will be experienced everywhere, impinging on everybody and everything, and they will increasingly demand responses at the international level—also for museums. Museum professionals at institutions such as The American Museum of Natural History and The Climate Museum in New York, the National Museum of Australia, Canberra, the Varanger Museum in Norway, and the Coalition of Museums on Climate Change established in Canada, have defined a number of objectives as a starting point for implementing action.

Firstly, museums should speak with one voice on the international stage. At present, the international museum movement is noticeably absent from forums such as the Paris conference or UN presentations.

Secondly, museums should be encouraged to develop as arenas for dialogue with NGOs and other community organisations and independent bodies at a local level, and governments and the UN on the international stage.

Thirdly, a wider engagement in the issues of climate change should be promoted among all museums, not only specialist museums, science museums or museums of

natural history. However, museums must also be prepared to relinquish some of their more cherished notions, such as neutrality and control over their own spaces (Janes 2015: p. 3). Art museums in particular have been willing to lead in this regard, e.g. C Words exhibit at the Arnolfini in Bristol (Payne 2015). Permitting artists and external curators to become initiators within museums spaces, lending the museum's authority to external initiatives. This approach could be extended to NGOs working on climate communications, but most of all to initiatives from local communities focusing on local issues. Broadly, the aim of the initiative from this handful of professionals is that all museums be perceived as catalysts for change: enhancing public awareness and inspiring public action.

By succeeding in bridging the gap between the local and the global in the communication of climate change, the museum may be seen to play a major role by the international community, as the site where the future dissemination of knowledge, gleaned by climate scientists the world over under the auspices of the IPCC can take place.

The international community has invested in the resources necessary to provide the scientific foundation for policymaker decisions over the last 25 years. There is now a comparable need to allocate resources to providing a comprehensive account of the challenges of climate change that is easily accessible for the general public. There is an increasingly urgent need to address dissemination to the public on the same scale as the earlier need for providing scientific proof to policymakers.

For instance, one could envisage the international museum sector cooperating with the United Nations in the dissemination of future reports. Museum professionals could be invited to design a dissemination project to communicate the contents of the 2018 report on the impacts of the 1.5° scenario. In conjunction with the publication of the report, this dissemination project might be placed at the centre of a world climate week during which museums around the world would be transformed into arenas where the public could participate in a programme of in-depth lectures, debates, discussions, exhibitions and events arranged either in-house or, preferably, in cooperation with other actors and best of all local communities.

This might seem to be located in the realms of fantasy. However, for fantasy to become reality only requires acceptance from the signatories of the Paris agreement that their citizens should be provided with a real opportunity to participate in the debates that will follow publication of the 2018 report. Indeed, there is a convincing argument that worldwide public participation is a precondition for successfully meeting the goals that the international community has committed themselves to in the Paris agreement. Museums, by offering an international infrastructure, unique dissemination skills and accessible arenas that bridge the local and the global approach to communication, can facilitate this goal.

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Engaging People with Climate Change Through Museums

Henry McGhie, Sarah Mander and Ralph Underhill

1 Introduction

Climate change is widely acknowledged as one of the most pressing, yet most complex, societal challenges. The topic has become established within the mass media and is periodically leading news, notably at the time of COP meetings, when the reporting language is typically high in hyperbole (rightly or wrongly), with repeated reporting of 'last chances' for 'a safe limit for humanity', and the 'failures' and 'successes' of various COP meetings and agreements (Bakaki and Bernauer 2017). Climate change is a classic example of a so-called 'wicked issue', one of those that are 'virtually intractable matters characterized by uncertainty over consequences, diverse and multiple engaged interests, conflicting knowledge claims, and high stakes' (Lorenzoni et al. 2006). The causes of climate change are invisible, the impacts distant to many, and both impacts and mitigation go far beyond the scientific sphere (although frequently reported and discussed in a primarily scientific context), but are entangled in the fields of economics, politics and sociology (Grundmann 2016). In European countries, awareness of climate change amongst

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adults is reported to be higher than 90% (Lee et al. 2015); in the UK, around two thirds of people in the Department of Energy and Climate Change attitude tracker reported feeling either concerned, or very concerned about climate change, although it was also ranked in the bottom three issues facing the country (UK Government 2014). Given the spatial and temporal distance of impacts, many people encounter climate change (a problem that is enormous and complex, yet is intangible and abstract) primarily through the media, which plays an important role in shaping people's attitudes to the topic (Carvalho and Burgess 2005; Boykoff and Roberts 2007; Martyniak 2014). This is the starting point and context for museums to engage people with climate change in meaningful ways.

2 Climate Change in Mass Media, and the Problem of Appeals to Fear

Climate change communication serves multiple purposes including advocacy and increasing scientific literacy, both as an end in itself, and to support climate adaptation and mitigation (Moser 2010, 2011). The means through which communication takes place and whether or not it provides the opportunity for dialogue and interaction all impact on its effectiveness (e.g. Shome and Marx 2009; Marshall 2014). For many people, media reports are an important source of information on climate change; however, the media is not a provider of impartial information, thus the framing of climate change within articles (Hajer 1995), along with the reporting of certainty/uncertainty in science, the accuracy of information (Boykoff and Boykoff 2004; Boykoff and Rajan 2007) and the relative balance given to competing perspectives (Allan 2002; O'Neill 2013) all affect how audiences make sense of the issue. For many this makes for a situation that is confusing at best, and misleading at worst.

When communicating about climate change, the imagery used can be an important element of framing and messaging. Within the mass media, the images and narratives of climate change frequently focus on extremes: of collapsing ice-sheets, Polar Bears on ice floes, storms and floods (see, e.g. Metag et al. 2016). While these stories attempt to communicate information on the topic, they are simultaneously having an effect on people's emotional state, influencing their motivational state and, consequently, their decision making and personal behaviour. Fearful representations of climate change, including familiar climate change icons such as Polar Bears and graphs of temperature rise, whilst being memorable, have been found to distance people and reduce their sense of engagement with the issue, and reduce their sense of their own ability to take action (O'Neill and Nicholson-Cole 2009). More encouragingly, the same authors found that imagery could also have positive effects on participants' attitudes and motivational state. Images that made participants feel most able to do something about climate change

tended to show activities linked to energy and energy saving devices in people's homes (thermostats, low-energy light bulbs, solar panels, wind turbines) and transport choices (cycling and trams), connecting with people's day-to-day activities and lifestyle choices. Similar results have been found in the UK, US and Australia (O'Neill et al. 2013), and in Germany, Switzerland and Austria (Metag et al. 2016).

2.1 A Role for Museums

Where might people find sites where they could engage constructively and creatively with climate change? Universities are among the institutions considered 'most likely to tell the truth' by the public about climate change (Poortinga and Pidgeon 2003); museums are also trusted institutions, in contrast to media and governments (Britain Thinks 2013). University museums could present a particular opportunity to engage the public with climate change as their university contexts provide a mandate to promote critical thinking. They should aim to be centres of excellence in terms of engagement, just as their parent universities aim for excellence in research and student teaching. As one commentator noted (writing in the context of university art museums), university museums are 'institutions that are, at their best, equal parts classroom, laboratory, entertainment center [sic] and spiritual gym where good ideas are worked out and bad ideas are worked off' (Cotter 2009).

Museum exhibitions and events can go beyond merely presenting people with information (held to be objective or otherwise) to connecting them with, and in, debates and discourses. Involving academic thinking and academics can support the development of fruitful museum experiences, although their work can require 're-purposing' or revising to be suitable for general public 'consumption'. Those working with topics on a day-to-day basis may not be best placed to reinterpret them for general audiences, using specialist language, or working with timescales that are difficult to imagine. The nature and scale of the challenges faced due to climate change can lead to academics presenting narratives that leave a perplexed public unsure of what it can do, inhibiting public action (see Moser 2016; Swaisgood and Shepperd 2010). This gives a clear role for museum workers as intermediaries and interpreters, providing opportunities for dialogue and the tailoring of messages to people, mixing messages of hope with reality, information with activity, and promoting personal and collective action.

Universities typically have broad partnerships that can be tapped into to connect the public with broader social and political agendas. This means that university museums can produce new spaces for dialogue and engagement, helping bridge the gap between policy/strategy and people's lived experience. Museums can also become sites for deliberative democracy, where people can contribute towards the development and delivery of public policy (even unknowingly) through debate and dialogue, provided they do not frame topics as simple problems to be solved (Cameron and Deslandes 2011).

2.2 *Engaging People Meaningfully with Climate Change*

Museums typically aim to educate, engage, entertain, inform and inspire their visitors and other users, yet, as previously noted, messaging and imagery used in exhibitions and public events can inhibit people's ability (or sense of their ability) to take personal action related to the topics presented. Consequently, museum workers need to ensure that they are both educating/informing and inspiring, rather that simply providing information. Those who develop exhibitions and public events in museums make choices and decisions, either consciously or unconsciously, based on their assumptions about their audiences, and about what they aim to achieve as a result of their activities. They could choose to regard visitors as passive recipients of information, working on the presumption that it is a shortage of information that is inhibiting climate change action (an information-deficit model), or they could—more constructively—help people explore climate change more creatively, shaping their own understanding of the problem and possible solutions. Museums could take some [more] responsibility for the way that their activities make visitors feel, both about the museum and about the wider world (Janes 2009, 2016; McGhie, in press).

3 Manchester Museum's Approach to Engagement on Environmental Issues

Manchester Museum is one of the oldest parts of the University of Manchester, having opened to the public in 1891, and is the largest university museum in the UK. It is also unusual in that it's collections and programmes cover both natural and human heritage. It has around 450,000 visitors each year, most of who come from the North West; around 10% of visitors are students and academics of the University. The museum plays a key role in delivering the University of Manchester's social responsibility strategy. The Museum's work is directed towards two goals: promoting understanding between cultures and working towards a sustainable world. These goals set both an aspirational destination and a direction of travel. Work around environmental sustainability has focussed on repurposing and repositioning 'museum natural history' to become more about people and natural heritage. The Museum's work has come to focus on positive outcomes for people as individuals, collectively and for the wider natural environment, combining health, wellbeing, creativity and environmental sustainability to create public and social value (e.g. McGhie 2012, in press). Exhibitions and programmes do not necessarily provide people with answers, but aim to promote critical thinking, participation and progression. Increasingly, the Museum's exhibitions and programmes aim to help people explore and express their own values, which underlie their attitudes and behaviours. This builds on a body of work in the applied social sciences, much of it done in partnership with, or commissioned by, nature

conservation organisations, and which seeks to address structural problems with contemporary society in regard to social and environmental sustainability (e.g. Blackmore et al. 2013a, b).

3.1 'Living Worlds'

The Museum's former Mammal Gallery was redeveloped into 'Living Worlds' in 2011, as the previous gallery did not readily connect with contemporary environmental issues or with the two themes of work outlined above (see McGhie 2012) (Fig. 1). The gallery was developed around the theme of exploring 'the natural world and people's relationships with it', a deliberately ambiguous statement that could refer equally to people collectively or individually. This ambiguity enables a set of shifting relationships between the visitor (–viewer–participant), wider society and the natural world, permitting the visitor to situate themselves within these relationships in a personally meaningful way to find their own level of challenge and meaning. 'Living Worlds' drew upon three strands of thinking. The first was a typology of nine basic human attitudes to nature developed by US sociologist–ecologist Stephen Kellert, formerly of Yale University. Kellert's method has been

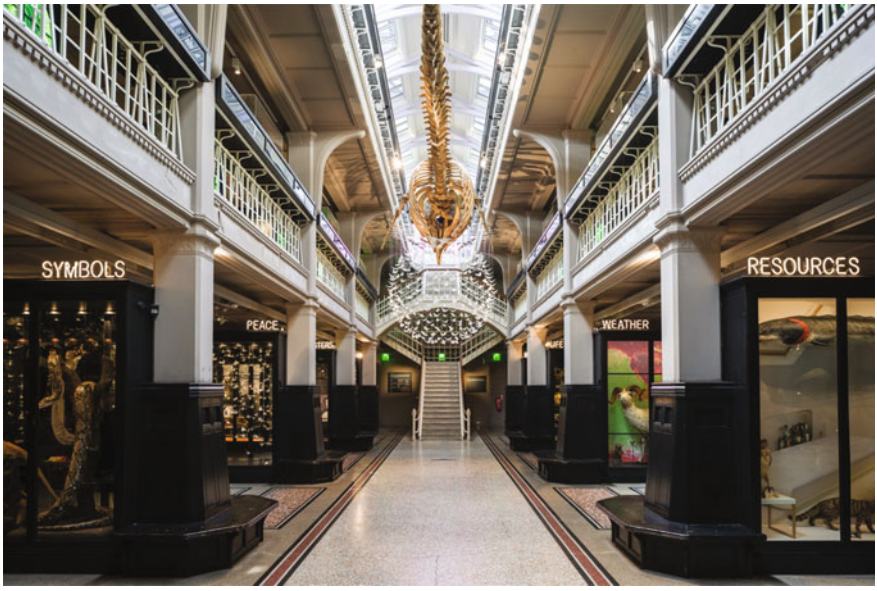

Fig. 1 Living Worlds, Manchester Museum (© Gareth Gardner)

used in many studies around the world since the 1970s, demonstrating statistically significant differences in attitudes to nature based on people's age, gender, cultural groups and occupation (see Kellert,1996 for an overview). While this work has been influential in a range of fields (e.g. children's education, nature conservation and applied psychology), it still appears to be little-known in the museum sector despite its obvious relevance. This work was expanded to connect the basic attitudes Kellert uncovered with the Biophilia Hypothesis, which posits that humans have innate relationships with nature based on a variety of material, emotional and social needs, shaped through our evolutionary history (Kellert and Wilson 1993; Kellert 1996, 2012). This work can serve as a powerful model for developing exhibitions and events, where visitors and participants are in mixed groups or come from different backgrounds and have different, and sometimes competing, interests. It helps (or it could help) museum workers consider how their activities can connect with a broad audience, and avoid talking about scientific things in scientific ways that, ultimately, only readily connect with scientifically minded people.

The second piece of work that was influential to 'Living Worlds' related to concerns about mobilising people in the face of potential 'bad news' stories. We drew upon work that promoted behaviour change, notably a piece of work by 'Futerra', a London-based sustainability communications agency (Futerra 2010). We were in full agreement with Futerra's proposition that "people will protect nature because they want to, not because they have to". The third strand of thinking was the 'five ways to wellbeing', developed by the New Economics Foundation, which identified five pathways to positive wellbeing: connecting with the world around us; keeping active; lifelong learning; taking notice, and sharing/giving (see Aked and Thompson 2011). We drew from these pieces of work to construct a narrative that nature is amazing, the world is full of wonderful things, people can have positive and negative effects on the world around them and our everyday choices matter, consequently, it is important that people connect with the world around them. We wanted to connect with people's lives, before, during and after their visit, supporting and encouraging them to engage with nature both for their own wellbeing and for the benefit of nature (McGhie 2012).

Each display case was developed as a stand-alone installation, which could be explored in isolation. Complex or broader topics, such as climate change, could be explored by reading across the different installations (e.g. 'weather', 'disasters', 'resources', 'variety of life', 'humans'), whether as part of self-led visits or as part of organised events. Neon signs on the tops of display cases made it easy for most people to select which cases they wished to engage with. Case titles were 'depoliticised', so that sustainability was explored in a case entitled 'Resources', climate change was introduced in a case entitled 'Weather' and biodiversity was entitled 'Variety of Life' (Table 1).

Table 1 Installations in the 'Living Worlds' gallery and suggested ways that they can be used to engage people with climate change

Installation title (and topic)	Contents	Possible connections with climate change
Connect (connections between ourselves, our choices and the natural world)	Three dioramas, of taxidermied British predators, jungle animals and a Polar Bear, 'breaking out' of their dioramas	The importance of everyday choices, of the interconnectedness of people and the environment, of connecting with the world around us as individuals
Domination (control of nature due to fear and admiration)	Taxidermy trophy heads and Tiger, Elephant tusks (presented with trophy photographs)	Links between climate change, geopolitics and capitalism. Inequalities between nations, social groups and the natural environment. Inequalities in climate change impacts and greenhouse gas emissions
Symbols (importance of nature for constructing meaning)	Taxidermy Eagle, Lion, Snake, Swan, Stork and Bees, (accompanied by images and objects showing them as symbols)	What climate change means symbolically: confirms or refutes, what it can be taken to presage, how it links with world views on the relationships between people and nature, drawing on religious views and ideologies
Peace (the importance of nature in helping people face personal difficulty)	Taxidermy Crane and piece of rubble from the Hiroshima atomic bombing (presented with a thousand origami Cranes)	How people could come to terms with climate change, and/or rebuild or adapt to climate change impacts, and/or links between sustainability and warfare
Disasters (natural and human-induced)	Plaster casts of woman and dog killed by volcano at Pompeii (presented against backdrop of image of lava)	How climate change will affect people around the world, and the connections between human-induced and so-called 'natural' disasters
Experience (how people understand the natural world)	Mounted birds and animals linked to childhood stories; collections of insects, minerals, display of mounted garden birds, glass lantern slides	The links between people's personal experiences of the environment, and how these may or may not be changing
British Wildlife (changes over time)	Mounted animals and plants reflecting conservation successes, effects of farming, introductions, and the importance of UK wildlife (presented against images representing each topic)	How British wildlife is changing as a result of climate change

(continued)

Table 1 (continued)

Installation title (and topic)	Contents	Possible connections with climate change
Humans (evolutionary connections between people and animals)	Skeletons of a Human, Gorilla, Chimpanzee, skulls of Primates and fossil Humans	How humans have altered the environment over long periods of time, and comparing/contrasting long-scale environmental change with rapid environmental change linked with fossil fuels usage and consumption
Bodies (adaptations to different lifestyles)	Skeletons of birds and mammals	How our bodies rely on ecosystem services. How different animals are adapted to particular climates, and might be affected by/respond to changes in climate
Life (the uniqueness of life as a process)	Specimens representing life (giant egg), growth (slice of wood), eating (shark jaw), movement (Hummingbirds), death (Dodo head)	The fundamental processes of life in terms of energy, growth, reproduction and death, and how climate change might affect these
Weather (weather and climate over time)	Coal, fossils of tropical and cold climate animals from Britain, species undergoing changes in range and the timing of events at the present time (presented against giant map and with LED displays with facts about climate change)	The link between weather and climate. Links between resource usage and human-induced climate change. That the climate has altered dramatically in the past, and people have not always been able to cope with their environmental conditions
Resources (everything we use ultimately comes from nature)	Species we use and have affected by our uses, e.g. mounted sheep wearing a woolly jumper (display case fitted out as inside of an apartment)	Renewable and non-renewable resources. Depletion of resources through human action
Variety of Life (the richness of biodiversity)	Specimens of species that have become extinct or that are rare	Many species are vulnerable to extinction and their futures depend at least partly on human action and choices. Many species are threatened by climate change

3.2 'Climate Control'

Manchester held the designation of European City of Science (ECOS) in 2015–16. Manchester Museum wanted to play a significant role in ECOS and chose climate change as its main topic for exhibitions and programming, recognising it as a topic that reaches beyond the purely scientific and relates to people's everyday lives, but

where there is widespread misunderstanding. Manchester's history and heritage are intimately connected with the Industrial Revolution, itself intimately linked with climate change. We wanted to go beyond well-worn stories of disappearing ice-caps, disappearing Polar Bears and the attribution of particular extreme weather events to climate change. Instead, we aimed for a highly creative programme, encouraging people to consider and express their own thoughts and values on the topic, and providing a critical framework for creativity, discussion and dialogue. Through this approach, we looked to create a different 'space' within which climate change, impacts, mitigation, and adaptation could be explored. Throughout the programme, we were cautious of balancing interactivity (e.g. asking people to contribute their own ideas and suggestions) with the provision of factual, but potentially depressing and/or frightening, information. The exhibitions were developed in consultation with the Public Interest Research Centre, and aimed to support and promote values related to self-direction, creativity, universalism and benevolence (see Blackmore et al. 2013a, b). The programme was developed in close partnership with the Tyndall Centre for Climate Change Research, with support from an Engineering and Physical Sciences Impact Accelerator Award, and with the Global Development Institute (both part of the University of Manchester).

The title 'Climate Control' was used to subvert the narrative of hopelessness that exists in mass media reporting of climate change, and drew on the idea of the Anthropocene. The motif of the Peppered Moth was chosen to badge the different exhibitions and all other elements of the programme. This moth was white (speckled with black) at the start of the Industrial Revolution but a black variety (called *carbonaria*) replaced the pale moths in industrial areas of the UK. Since the Clean Air Act (1956), black moths have declined to be replaced once again by white moths. The story of the Peppered moth is a Manchester story: the first black moth was found in the city during the early nineteenth century. Moths are also a symbol of change and transformation. All of these made the moth an ideal motif: something surprising, unexpected, creative and non-threatening; which shows the relationships between people's actions and their environmental effects; that transformation and change can be possible, and that has local relevance.

The main exhibitions of the programme explored the ideas that 'we can't change the past' but 'we can change the future' (these ideas were presented as large neon-type signs). As visitors approached the exhibition they were faced with two entrances (choices): 'explore the past' or 'explore the future'. Visitors were free to choose where they entered the exhibition, but by having to make a choice they were given agency over their experience, which we considered important to engaging them with the topic of climate change more broadly (Fig. 2). 'Explore the past' had a black interior, with basic but fairly hard-hitting facts on the causes and impacts of climate change; these were 'softened' by using a hand-written font (Fig. 3). Exhibits linked 350-million-year-old coal and plant fossils, with people's experiences of climate change today, and the effects of climate change on the Arctic as a barometer/early warning system of climate change. Stories of people's varied experiences of climate change were drawn from '*Adventures in the Anthropocene*' (Vince 2014). A Polar Bear on open display was 'reclaimed' by projecting the words' 'beautiful', 'free',

Fig. 2 The two entrances to the main Climate Control exhibition, giving visitors control over their own experience of the exhibition (© Gareth Gardner)

Fig. 3 The interior of the main Climate Control exhibition, showing the strong contrast between the black interior of 'we can't change our past' and the white interior of 'we can change our future' (© Gareth Gardner)

Fig. 4 The 'reclaimed' Polar Bear, showing the word 'free' projected on the wall, and the 'transition zone' of Peppered Moth images (© Gareth Gardner)

'wild' and 'are we so different?' on the wall behind it. Visitors were encouraged to sit and look into the Polar Bear's eyes with the aim of promoting reflection and empathy. The two 'halves' of the exhibition were connected by a series of acrylic panels with huge Peppered Moths, both black and white as a 'transition zone' (Fig. 4). 'Explore the future' did not contain museum objects, but was a place for people to read about climate change, share ideas they had on a large board entitled 'blue skies thinking' (again with a large neon-type sign). Information on what is happening locally, nationally and internationally around climate change action enabled visitors to choose their own scale at which to consider the topic.

The exhibition offered diverse opportunities for visitors to interact and engage with the topic. Volunteers invited visitors to touch and explore museum objects relating to the subject, and to talk about climate change in personally meaningful ways. Visitors could also have discussions with climate change experts and enthusiasts on a daily basis. This last element, the 'Climate Exchange', aimed to give large numbers of academics (over 150) an opportunity to talk with people about their work with the aim of two-way exchange and impact. Visitors were able to create a visual representation of their individual and collective carbon footprint by adding black adhesive stickers to a white wall, with the interpretation that 'we all make a difference'; this wall was in the half of the exhibition that explored the past and gradually got blacker over time through collective actions (Fig. 5). On the reverse side of the wall, visitors were encouraged to add white moth-shaped stickers to a black wall with the interpretation that 'we can all make a positive impact'; most

Fig. 5 'Together we all make a difference' interactive, showing black stickers added by visitors, representing their individual carbon footprint. Note how carefully visitors have avoided covering the exhibition text (© Gareth Gardner)

visitors wrote ideas and comments on these moths before adding them to the wall, which gradually turned white through collective actions. As they left the exhibition, visitors were encouraged to share their thoughts on climate change by adding tokens to ten large jars with questions about climate change on the side, tapping into the familiar idea of a penny jar (the jars were plastic sweets jars). This interactive aimed to encourage people to consider their own viewpoints and values, to be able to see other people's viewpoints and values, and to encourage the expression of collective values.

In the 'Living Worlds' gallery, a giant (3-m diameter) sculpture of white Peppered Moths was added as a statement piece that will continue to hang in the gallery as a legacy of the project (Fig. 6). The gallery was supplemented by large graphics with 'ten ways to make a difference', placed among the permanent exhibits. Visitors were invited to add tokens to large jars next to each of these graphics to let themselves, and other visitors, know whether they already did particular actions, they might do this, or they did not want to do this; the results of the voting are discussed below.

Fig. 6 The sculpture of Peppered Moths, added to the Living Worlds gallery in 2016 (© Gareth Gardner)

An extensive programme of public engagement events sought to provide many entry points to the topic in a range of formats. These included film-screenings of climate change themed films (e.g. A Day After Tomorrow, The Island President); monthly 'Big Saturday' family-themed events on a broad range of topics and including many academics with table-top activities, and reimagining Manchester out of Lego during the school holidays. This program aimed to provide opportunities for public engagement with different levels of science and technology at the same event. For example, as part of the Manchester Museum Big Saturday programme, participants had the opportunity to learn about a technology for removing CO_2 from the flue gases of large point sources such as power stations (Carbon Capture and Storage). A series of activities could be delivered with different levels of detail, depending on how members of the public wished to engage. These ranged from simply discussing the process with experts through to performing CO_2 capture experiments and exploring the rocks in which CO_2 would be stored. Many of these events offered a multisensory experience. An art performance—Climate Synaesthesia—took visitors through images, sights, sounds and smells of climate change, exploring alternative ways of presenting complex climate change data.

At the same time as Climate Control was on show, Manchester's climate change strategy and action plan were being refreshed. The Museum worked in partnership with Manchester Climate Change Agency, which has responsibility for developing and realising strategies and action plans for climate change management and engagement in the city, with the aim that visitors to the Museum would be better equipped (in terms of information and an understanding of 'what mattered to them') to engage with the shaping and delivery of the strategy and action plan. The Museum provided opportunities for members of the public and those involved in shaping climate change policy/strategy to meet face to face, and to better understand one another's positions.

Over 91,000 people visited the 'Climate Control' exhibitions and took part in events, and over 2,500 people took part in one-to-one conversations as part of the Climate Exchange. Visitors contributed 21,850 black dots to the 'collective impact' interactive (Fig. 5), and 12,168 moth-shaped stickers with ideas and personal commitments on climate change action. Voting jars, where visitors expressed their personal opinions by adding plastic tokens, showed that 73% of visitors cared that the climate was changing; 70% thought they would be affected by climate change; 82% of people cared about nature, and 69% of people considered that what they did in their lives had a direct effect on the world; over 42,000 tokens were added to these jars. A further 69,380 tokens were submitted to the 'ten ways to make a difference' interactive (see Fig. 7). These large figures demonstrate the tremendous potential of museums for capturing information on public opinion, and for the public to gain information on the views of people who have had a similar experience to themselves.

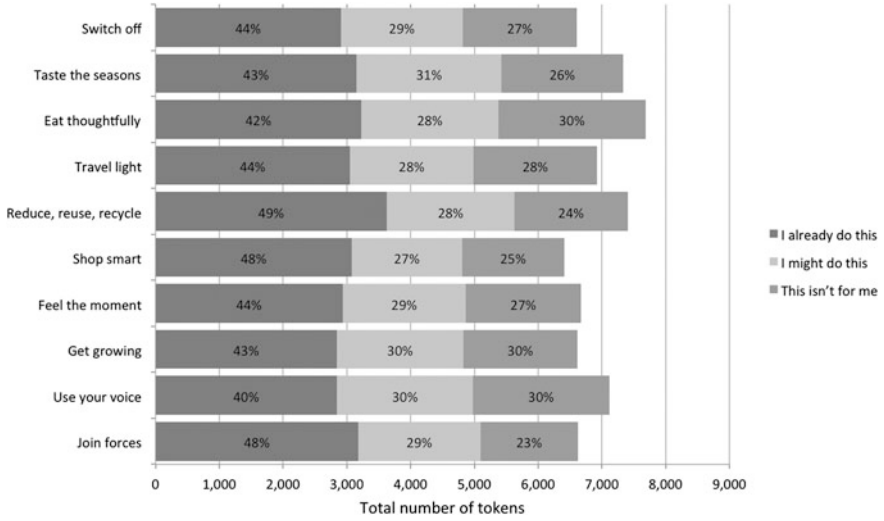

Fig. 7 Results of voting from the 'ten ways to make a difference' interactive. Percentages are the mean of counts that were undertaken approximately weekly throughout the period of the exhibition

4 Discussion

To date, climate change engagement has often focused on communicating information, often as set of issues, with less attention given towards providing people with the emotional skills to connect with the topic (inspiration and motivation) (see Moser and Dilling 2011; Moser 2016). For engagement to be more than communication, it has to enable cognitive, affective and action responses (Lorenzoni et al. 2007; Moser and Dilling 2011). This chapter has aimed to provide some examples of how academically rigorous information, coupled with engagement practices that aim to support personal action and motivation, can provide opportunities for producing transformational experiences (well-informed and well-produced). By providing these experiences, museums can play their part in promoting individual and collective action around climate change, with the aim of debunking myths, encouraging individual action (as illustrated in Fig. 1 with people responding that they may take particular actions), and sign-posting people to activities that they can take part in, should they want to. Mindful of the diversity of people who visit museums, it is important that activities provide opportunities for engagement, connecting with people through a range of activities involving thinking, feeling and doing. Visitors should also leave having found their visit enriching (however defined) and likely to return again. For academics and science communicators, working in partnerships with museums offers the opportunity to reach new audiences.

The icons of climate change, for example Polar Bears and lumps of coal, already feature in natural history museums, meaning that they are already part of the

expectation of what people will see: they are elements of the museum frame. These objects, however, can be used in new and creative ways by inviting visitors to not only see them, or sometimes even to touch them, but to connect with them and the broader topics they relate to through exploring stories and ideas with museum staff. They can be used to disrupt commonly held ideas or frames around climate change. Further opportunities for dialogue and two-way communication, such as the Climate Exchange and Big Saturday events, proved effective in making climate change more personal, with members of the public able to form views of the science and possible actions through discussion. These approaches were considered to be particularly effective in building social trust (Cvetkovich et al. 2002) and can be more effective than one-way communication in empowering communities to take action (Renn 1992). Aspects of the exhibition and programme of events were multi-sensory and others arts-based in their approach. Creative approaches to engagement tap into the affective domain of learning (Friedman 2013) and may be more effective than approaches that are purely cognitive (see also Moser and Dilling 2011).

While this paper has explored some of the ways that critically informed exhibitions can be developed in museums, there is a need for greater evidence on the impact of such exhibitions and related engagement activities. However, evidence of pervasive change in attitudes and behaviour can be difficult to capture, quantify or attribute towards particular exhibitions or activities. Temporary exhibitions, which are typically of relatively short duration (4–5 months) can help to create relationships with audiences and with partner organisations, but require sustained activity in order to be maintained. Permanent museum galleries provide an opportunity for such sustained activity, as they can be refreshed periodically, providing new opportunities for public engagement. Future work will be directed towards better understanding the impact of such work, and international co-operation with other heritage organisations to develop shared and distinctive perspectives.

5 Conclusion

Museums have tremendous potential for promoting public discourse and engagement around contemporary issues such as climate change. They provide (potentially) one of the few venue types where people can express their feelings and values beyond their immediate social circle, something that schoolchildren and students enjoy but which is typically not available to adults. Museums offer adults the space and opportunity to continue to learn and engage with new ideas and concepts, and to interact with other people as a shared cultural and learning experience. Museums can help people find out what they think about environmental issues and what other people think; the can provide opportunities for people express themselves to others. In this, museums have a civic–social function that they would do well to take very seriously. Museums could also connect people with the bigger picture and can provide people with a frame within which to reflect on, and debate upon, people's place in the world (individually and collectively) and to explore

timeframes beyond the day-to-day or short-term. Given the obvious social dimensions of interventions and policies to mitigate climate change, once taken outside the museum, the learning that has taken place within a museum can also provide a context in which wider societal debates can take place.

Connecting museums with issues of social responsibility and social justice (including climate change and environmental sustainability) is not a new idea, but it has been adopted with variable levels of support by various museum types (e.g. Davis 1996; Janes 2009). However, if museums choose to sit on the fence, at best they impede the reduction of inequalities and, at worst, as trusted institutions, they give tacit approval for these systems and reinforce them, obstructing constructive change (see, e.g. Marshall 2014: 99–104; Evans 2015; Janes 2016). Museums with natural heritage collections can, and surely should, do a lot in terms of connecting people with issues of environmental sustainability and nature conservation, just as those with collections of cultural artefacts can connect with contemporary issues of cultural diversity and social sustainability. Climate change, as a scientific–social issue, presents an opportunity for museums of many kinds to connect with a theme of wide-scale importance, and for widespread public benefit. Through doing so, museums can create real and impactful public value, delivering positive benefits for society and the environment, and concurrently building a stronger purpose for themselves.

Suggested Key Points to Consider for Climate Change Engagement in Museums

- Be clear on what you are trying to achieve: are you interested in what people do in the museum, or beyond the museum?
- Ask yourself seriously whether you are enabling or disabling climate action.
- How are you promoting critical thinking?
- Be clear on what assumptions you are making about your audience, who they are, what they know and what they want from their visit.
- If you are not confident in the topic, don't be tempted to play down the science or importance of climate change, or to present false 'balance'.
- Don't overinvest space and time in persuading people climate change is 'real': focus on critical thinking skills, and imagining and exploring solutions instead.
- Disrupt general narratives of hopelessness and inevitability to encourage positive action: tell a different story.
- Symbols, images and ideas can be just as important as graphs and facts—or even more important.
- Use creative experiences to encourage people to find their own words, ideas and symbols that can promote positive actions around climate change.
- Balance challenge with support, and positive and negative information.
- Be both brave and empathetic.
- Give people some agency: allow them to imagine and create solutions that work for them.
- Give people plenty of chances to respond to exhibitions and events.
- Allow people to connect issues and solutions of similar scales.

- Create a platform for people to explore and express ideas around citizenship and the world they want, and to explore the impacts of that world both nearby and farther afield.

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Considering the Role of Government in Communicating Climate Change: Lessons from the US Public Flood Insurance Program

Chad J. McGuire

1 Introduction

Coastal real estate in the United States is, on average, more valuable than similar properties located inland from the immediate coast (Bourassa et al. 2009). Effectively, the same house with the same land area will be worth more immediately along the coastline than it would be worth some distance away from the coastline. The reasons for this difference have to do with relative demand for coastal living. Higher prices are paid for coastal properties because demand matches or exceeds available supply, and also because buyers are willing to pay a premium to live in close proximity to the ocean. The high demand for coastal proximity is show in current population distribution; the current US population is distributed heavily towards the coastline (NOAA 2013).

This preference for coastal living, reflected in higher valuations of coastal homes, must be reconciled with the current state of knowledge about the *risks* associated with climate change. Strong consensus in the scientific community shows that climate change is occurring, that this change includes sea level rise, and that the risks of coastal living in most areas of the United States is increasing. For example, the Gulf of Mexico and eastern coastline of the United States have historically been prone to hurricanes and related natural disasters that disproportionately impact these coastal areas (NRC 2014). But over the past decade these areas have incurred some of the most costly damage in coastal disaster history. Hurricanes Katrina and Rita in 2005, and Superstorm Sandy in 2012 are recent examples. Katrina and Rita are estimated to cost well over $100 billion in damages, while Sandy is currently at $75 billion in damage estimates. While there is no conclusive link between climate change, sea level rise, and these specific storms,

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scientific consensus suggests the effects of climate change provide the inputs for increasing coastal storm frequency and intensity. Higher seas allow for storms to approach closer to land and intensify storm surge inundation, while warming ocean surface temperatures provide fuel for ocean-borne hurricanes (Church et al. 2013).

Given the above, the question becomes one of trying to unravel why sufficient demand exists to support higher prices of coastal homes in coastal areas that pose current and increasing risks to those homeowners under conditions of climate change? Said another way, why would people pay more to live in a dangerous area than a less dangerous area inland from the coastline? Certainly there are multiple factors to consider. For example, in free markets economies like the United States real estate market, the price paid for a given home is not set, but is rather the result of relative supply and demand (Case and Shiller 1989). Thus factors affecting *both* supply and demand must be considered.

On the supply side of the equation, there are many factors affecting the current stock of coastal real estate. For example, there is no possibility of expanding development seaward into the ocean. Reclamation projects that include the filling of coastal areas for development are mainly historical and have not been an appreciable means of new coastal development since the enactment of relevant laws like the Federal Clean Water Act (Rosen and Katz 1981). In addition, land use preservations laws at the federal, state, and local level have all aided in limiting the supply of new coastal construction in many areas (Katz and Rosen 1987). Due to these and other factors (see Saiz 2010), supply of in-demand coastal homes is limited in many areas of the US.

Assuming stable supply levels, demand for coastal housing should be the ultimate controlling factor. One would expect to see this where there is price appreciation for existing coastal homes, and there is a premium willing to be paid for new coastal development in the limited areas this is possible. And in fact this is precisely what is seen. Demand remains high for coastal development when one looks at price support in the sale of existing homes (Rappaport and Sachs 2003). Of course the demand is not static. This fact is encapsulated in a recent study showing a depreciation of price levels just after a serious natural disaster, with a return to a higher price support after approximately six months (Atreya and Ferreira 2014). This would suggest that *risk* does impact price levels, and thus demand, but the influence of risk diminishes as time passes from recent disaster events. In other words, one's internalization of risk varies with time from a natural disaster. When the disaster is close in time, there is a greater internalization of risk. When the disaster is further removed from the present, there is a tendency to discount the risk. Studies have confirmed this time-based discounting of risk (Speyrer and Ragas 1991; Harrison et al. 2001; Bin and Polasky 2004; Kousky 2010).

All of this leads to the search for factors that are ultimately propping up the demand for coastal real estate in the US. Certainly part of the demand has to do with the benefits of living near the coast, such as the view of the coastline and the ease of

access to water and near water related activities: sunbathing, swimming, and boating are all examples (Bin et al. 2008b). The values of these benefits have been assessed in a variety of studies, all showing an enhanced value associated with living within immediate proximity to the coastline (Bin et al. 2008a; Landry and Hindsley 2011).

Beyond the more obvious factors supporting demand, there is one critical factor at the center of this paper, and it has to do with how risk is being communicated, or not communicated in this case, through existing government policy. Specifically, how much demand for coastal living is supported by both the National Flood Insurance Program (NFIP)—the public flood insurance program of the United States—and the federal disaster relief program that provides federal money to rebuild in coastal areas after a disaster?

What follows is a historical and contextual treatment of the NFIP program that provides insight into how previous and current government policy can *increase* the demand for coastal homes through a process that artificially *decreases* the perception of risk by those who collectively create the demand for coastal living (current and potential coastal homeowners, coastal developers, local municipalities, etc.). In summary, the current program charges below-market premiums and provides disaster relief assistance in a way that distorts the carrying costs of coastal living by artificially lowering those costs. The artificially lowered cost acts as a price signal for risk. Thus, when the subsidized cost of insuring against risk is artificially low, this communicates to the public that the actual risk is also low. The public then perceives the risk as low and acts accordingly. The result is a higher demand for coastal living that exists, in part, on discounting the risks of climate-induced coastal damage. The implications of such historical and existing policies interfere with ongoing efforts to properly communicate climate change risks to the public in the United States. Thus, if the US wishes to direct its citizens towards a clearer understanding of climate change, including its potentially harmful coastal impacts, then it must consider the impacts of existing policies on this larger goal and make changes to existing policy to properly match perceived and actual risks.

It is important to note that current research on the topic of coastal risk perception is multifaceted but not definitive. As noted in greater detail within this paper, mainly through indirect evidence such as policy tenure and price sensitivity, studies show there is a strong correlation between current coastal flood insurance policy and public risk perception. But there is no definitive study that provides evidence on exactly how a change in this policy would impact actions relative to coastal real estate demand. Rather the recommendations and conclusions drawn are based on inference from work on residential and commercial real estate insurance pricing models that do not contain subsidies or discounts.

2 Historical and Policy Context of Public Flood Insurance and Disaster Relief

The United States has evolved a system of public flood insurance over the last half century. Since 1968 the federal government has offered flood insurance as a means of sharing the risks associated with flooding (CRS 2013). The decision to offer flood insurance was catalyzed by two important factors. First, the federal government had historically provided de facto flood insurance through federal disaster relief (Pasterick 1998). Second, attempts by the federal government to foster a private flood insurance market were met with ultimate disinterest by the insurance industry due in large part to the risks involved, government involvement, and the lack of a sufficient pool to mitigate those risks (Grossman 1958; Anderson 1974; Knowles and Kunreuther 2014). The convergence of a lack of private interest to develop a flood insurance market and the existing policy of providing federal disaster relief to flood prone areas provided the impetus for a publicly backed flood insurance system across the United States.

The first iteration of federal flood insurance, the National Flood Insurance Act of 1968, was entirely voluntary. Existing structures in flood prone areas had the option to purchase flood insurance but were not required to do so. Under these voluntary conditions, flood insurance adoption rates were low (Michel-Kerjan 2010). Spurred in part by significant losses from coastal hurricanes, the United States amended its voluntary coastal flood insurance law with the Flood Disaster Protection Act of 1973, making it mandatory for communities located in what the amended federal law identified as 'special flood hazard areas,' or SFHAs. Communities located in SFHAs were required to join the National Flood Insurance Program (NFIP), requiring mitigation of flood threats including residences located in SFHA's and connected to federal programs (such as federally backed mortgage programs) purchase public flood insurance. Failure to join the NFIP, including meeting the best practice standards, resulted in the removal of federal disaster assistance for the area. Thus the overarching purpose of the 1973 amendments was to get communities to actively engage in flood risk mitigation, through best practices, while also ensuring coastal properties located in high flood risk areas shared some of that risk by purchasing flood insurance (Michel-Kerjan 2010).

Since 1973 the public flood insurance policy adoption rates have increased steadily, from approximately 1.4 million policies in effect in 1978 to a high of 5.7 million policies in 2010. Since 2010 policy adoption has seen small declines, with 5.6 million policies in effect for 2012 and 5.5 million policies in effect in 2014. Meanwhile the total property value insured for flood loss, controlled in 2014 dollars, has increased from US$183 billion in 1978 to a high of US$1.35 trillion in 2010. As of 2014 the total value of property insured for flood loss stands at US $1.28 trillion (McGuire 2015). These numbers suggest the 1973 amendments to the national flood insurance program have been successful in, at least, increasing adoption rates. Since mandatory insurance requirements were implemented, both

the number of policies in effect and the total value of property insured has steadily increased, showing only small decreases in the past few years.

An emerging practical goal of both the 1968 National Flood Insurance Act and 1973 Flood Disaster Protection Act was to transfer some flood risk from the government to private citizens (Pasterick 1998; Knowles and Kunreuther 2014). Recall that prior to 1968 there was no comprehensive flood insurance program in the United States (Anderson 1974). The low adoption rate experienced in the first decade after the passage of the law provides some evidence of how the historical policy created a kind of path dependence. Using the price paid to protect against flood risk as a proxy for risk perception, citizens were accustomed to discounting the risk of flooding when they were not required to insure against the risk (Slovic 1987, 1993). The 1973 amendments made marginal improvements, mandating coastal insurance in certain areas but heavily subsidizing the premiums paid. The mandate increased policy adoptions, going from 1.4 million policies in 1978 to 5.5 million in 2014. However, the mandate was likely less effective in moving public perception of flood risk closer to the actual and evolving risk of coastal living in many areas of the United States. One of the key anecdotal pieces of evidence for this proposition was the passage and, shortly thereafter, abrupt repeal of essential parts of the federal Biggert-Waters Act in 2013–2014.

The Biggert-Waters Flood Insurance Reform Act of 2012 amended the 1968 National Flood Insurance Act in ways that attempted to more rationally identify the actual risks of flood hazards by placing more of that risk on the shoulders of coastal homeowners (CRS 2013). The method employed to accomplish this goal was two-fold. First, flood maps were to be updated to reflect the best available science on flood risks. For coastal communities this included updated flood scenarios incorporating actual observed sea level rise. Second, the amount of subsidy provided by the federal government was diminished, phasing in market rates reflecting full risks of flooding without government subsidy over five years. The end result of Biggert-Waters reforms was that some coastal properties would be determined to be in flood hazard areas requiring flood insurance, resulting in the need to pay for the risk of coastal living. In addition, other coastal properties already existing in flood hazard areas would find themselves paying higher premiums then before, sometimes substantially higher premiums.

Biggert-Waters, once passed, became disfavored amongst coastal communities, their homeowners, and the real estate markets supporting those areas (Knowles and Kunreuther 2014). The result was a repeal of parts of Biggert-Waters related to premium increases while also enacting a four-year moratorium on insurance premium increases. In many ways Biggert-Waters was, metaphorically as a policy solution, a ‘poison pill.’ It was not poisonous because it was wrong in its ultimate goal of matching actual and perceived risks associated with coastal living. It was poisonous because it moved too far and too fast away from the expectations of a community that had become accustomed to the discounting of risk inherent in the history of national flood insurance. A path dependence had been created that externalized the risks of flooding, allowing a discounting of risk to support coastal communities (Tversky and Kahneman 1981; Slovic 1987). These supports include

the choice to invest in coastal infrastructure, the choice to live in risky coastal regions, and the assumptions underlying market valuations of many coastal properties. Similar kinds of path dependence have been shown in other contexts, such as climate change denial, where the information is seen as threatening to existing worldviews (Jacques 2012).

3 Influence of Historical Flood Insurance and Disaster Relief Policies on Communicating Climate Change Risk

There are real political consequences to altering community expectations, as the short history of Biggert-Waters shows. But hidden behind this immediate political lesson is a deeper issue about the relationship between policy development and risk communication defined by community expectations. Historical evidence shows the initial development of flood insurance policy had a rational goal: the slow shifting of risk from federal disaster relief (where government carries all of the risk) to voluntary and conditionally mandatory flood insurance (where government and citizens share the risk) (Michel-Kerjan 2010). But the initial goal has reinforced individual and collective decision-making about coastal living that discounts the actual risks involved in many coastal areas. The consequences are a path dependence defined by coastal living preferences, coastal housing valuations, and a myriad of decisions that rely—directly and indirectly—on the subsidy. Removing the subsidy to the extent Biggert-Waters attempted to do created a schism between preexisting expectations and the new policy to such a degree that the policy was seen as untenable by those most acutely affected (Knowles and Kunreuther 2014).

Contrasting the history of public flood insurance subsidy in the United States against the attempt by Biggert-Waters to remove the subsidy, which was wholly unsuccessful, highlights the political difficulties in seeking public acceptance of objective risks that do not align with the public's perception of risk. As noted, prior to 1968 there was no federal program for flood insurance in the United States. However there was federal disaster relief, which provided a de facto zero premium flood insurance policy (Grossman 1958; Anderson 1974). In addition there were public work projects and other government subsidies that provided incentives for coastal living (CRS 2013; Knowles and Kunreuther 2014). Collectively these conditions set the foundation for a rational discounting of risk. If it was really dangerous to live along the coast, then government would not be helping to provide infrastructure and subsidies for development, nor would it financially rescue coastal areas after disasters. The path dependence created by these historical conditions has only been partially addressed. Passage of a voluntary public flood insurance program in 1968, and then the amendments requiring mandatory flood insurance for certain properties in 1973, have marginally moved community perception of risk and actual risks closer together. Flood insurance in the United States is still highly subsidized and Biggert-Waters shows us that while there may be political will to

remove the subsidy, there is no willingness by the majority of the affected public to accept a higher perception of risk.

Meanwhile the actual risks associated with coastal living are increasing. The evidence for climate induced sea level rise is clear (Church et al. 2013). Historical and current observations alone show a trend where more intense and costly coastal storms along the east coast of the United States have happened in recent decades (NRC 2014). And the insurance payouts for flood losses have been substantial. From 2000 to 2009 the National Flood Insurance Program (NFIP) experienced a total of US$670 billon in losses (in 2009 dollars) (Michel-Kerjan et al. 2012). To place that in perspective, in 2014 the NFIP took in US$3.8 billion in insurance premiums to cover US$1.28 trillion worth of property, a ratio of insured property value to premiums charged of 336 to 1 (McGuire 2015). In addition, five of the six highest insurance payouts under the NFIP since 1968 have occurred since 2000 (CRS 2013). The numbers suggest vulnerable areas, particularly sensitive coastal areas, are becoming more vulnerable in the face of climate change (Wapner 2014).

Responses to recent storms along the coastal US have included a promise to 'rebuild.' New Orleans has seen a reinvestment in building and storm surge protection measures after Hurricane Katrina (Waugh and Smith 2006; Michel-Kerjan et al. 2012). There has been rebuilding in the wake of Hurricane Sandy in 2012 as well, but there has also been strategic decisions to not rebuild in the riskiest areas. Certain locations, such as historic marshland filled and developed along Long Island in New York, have been the focus of buyouts where the government purchases private property and does not rebuild, choosing instead to reestablish a natural buffer between the encroaching sea and upland areas (Binder et al. 2015) These recent choices to not rebuild in all areas are promising but both expensive and limited, mainly taking effect only after development and storm damage. Moreover concurrent government actions that counter buyout approaches, such as armoring existing shorelines, confuse the communication of a consistent policy approach by reinforcing the perception that these coastal areas are safe or being made safe through armoring and similar "stay" approaches.

4 Interpreting the Effect of Past US Public Flood Insurance and Disaster Relief Policies on Climate Change Communication

When one considers the role of government in communicating climate change, the actions taken by government to advance climate resilient policies must be balanced against previous and current policies that incentivize a discounting of climate resiliency, even if the intention of those policies are not overtly geared towards countering climate change goals. The historical and current practices of the US government's public flood insurance and disaster relief policies described above provide an important example to the larger role of government in communicating

climate change. Current or planned government policies that aim to identify the objective risks of climate change and have those risk disseminate into the population must not only be judged on their merits to accomplish this important goal, but contradictory policies—understanding contradictions can be explicit in the policy itself as well as implicit in the incentives created by the policy—must also be considered and their effects in climate change communication made part of the policymaking process.

As discussed, the US public flood insurance and disaster relief policies developed over time in incremental stages that were arguably rational government choices under the context and circumstances of the time. Before the NFIP was created in 1968 coastal property owners were effectively receiving 'free' coastal flood insurance through tax supported federal disaster relief. This meant that every citizen not living on the coast but paying taxes was subsidizing the risks of coastal living. The NFIP was passed because expensive disasters were occurring along the coastline, which was being developed rapidly. But due to political constraints, the NFIP began as, and has remained, a highly subsidized and minimally enforced program. So rather than require coastal homeowner's to bear the full risk of coastal living, the NFIP has created a small 'toll' that provides coastal homeowner's will significant protections against coastal risks, including risks attached to a warming planet.

The most important part of the current flood insurance and relief policy in the US is the connection between actual risk and perceived risk. Under ideal circumstances insurance premiums provide a signal about risk: the higher the premium the higher the risk. This is helpful to both the insurer and insured in many ways, with one important way being the insured does not have to fully understand or comprehend the actual risks involved. Rather the price they pay to insure themselves against the risk will 'signal' the actual risk. When the price of insurance is prohibitively high in relation to the value of the insured item, the 'expense' signals the risk and allows the consumer to make an informed decision, for example not to purchase a given coastal home because of the cost of the insurance, or alternatively to offer a lower price for the home to incorporate the risk of loss in the value of the property. Alternatively an overly low price of insurance signals a reduced risk, incentivizing the buying of coastal homes at higher prices that do not reflect the actual risks. When the price of insurance is artificially low, as through a subsidy, the perceived risk is low even when the actual risks are high.

Subsidized flood insurance creates the mismatch of a lower perceived risk in a world where the actual risks are much higher and, per the evidence, increasing through climate change. The subsidy itself is a kind of government communication about climate change, as is federal disaster relief that sits behind public flood insurance. Collectively these policies tell coastal homeowner's they need now worry about climate change impacts along coastal areas. The low flood insurance premium tells the owners the risk of flooding is low, even when it is objectively high and increasing over time. And federal disaster relief communicates that even if a disaster hits, the federal government will be there to help rebuild your home and pay for losses. The signal being sent is clear when viewed through the context of

climate change communication: climate change does not exist, or even if it exists, it does not pose a serious threat in sensitive coastal areas of the United States. Of course the state of scientific evidence, history, and reason suggest the opposite. As such, policies such as the NFIP and federal disaster relief must be reviewed in light of important new overarching government goals. Certainly this includes thinking about how these policies harmonize with advancing the communication and understanding of climate change in the wider population.

5 Confronting Path Dependencies Created by Existing Flood Insurance and Disaster Relief Policies in the US

Overcoming a path dependence built on a long history of subsidy is difficult. Current evidence suggests US citizens will likely continue to exhibit a preference for coastal living (NOAA 2013). And so long as government continues to subsidize the risks involved with coastal living, particularly in vulnerable areas, there is little reason to assume drastic changes in public preference will emerge anytime soon. For example, doubling down on hard armoring the shoreline in risk prone areas, even after a storm event, will tend to reinforce the idea the place is safe. Even if an event challenges the public's low perception of risk, government spending to 'protect' the shoreline will likely have the effect of reinforcing a low perception of risk ("it may have been dangerous before, but government would not have spent all that money unless the wall has removed the risk") (Tversky and Kahneman 1981; Slovic 1987).

There is also evidence to suggest elected officials will be more apt to spend money on disaster relief because the voting public is more apt to reward direct relief payments rather than planning to prevent damage from coastal disasters (Healy and Malhotra 2009). In other words, politicians will continue to find reason to reward risky behavior through current polices that act at cross purposes to a separate policy goal of communicating the risks of climate change so the public understands and internalizes this risk into their daily lives. All of this suggests the ability to effectively communicate climate change in coastal areas is frustrated by the current path dependence created under the NFIP and federal disaster relief programs. So how can the existing national flood policy be modified to better communicate risk? Some small changes may provide ground to be gained by utilizing flood insurance itself as a mechanism to bridge the gap between actual and perceived risks associated with coastal living.

Even though Biggert-Waters was ultimately limited in its attempt to rationalize coastal flood insurance in the United States, it correctly signaled the need to better match perceived and actual risks associated with coastal living (McGuire 2014). Again, using the premium paid for flood insurance as a proxy for risk perception, governments can look to the US example as a way of thinking about better communicating changes in risks associated with climate change (Kasperson 1986;

Slovic 1993). For the US it may be that insurance premium adjustments have to occur more incrementally over a greater period of time (something less than the 25% per year towards full risk premiums required by Biggert-Waters). But in order for this to work, the premium adjustments must be such that they reach the actual risks posed, accounting for increases in actual risk due to ongoing climate change. For example, if actual risks were increasing each year in a coastal area by 1 unit per year, then the increase in insurance premiums must be such that the perceived risk increases more than the 1 unit per year of actual risk.

Beyond ensuring the insurance premiums result in perceived risk outpacing any increase in actual risk, the overall time in matching perceived and actual risks must be considered. For example, if a community is only coming close to internalizing the actual risks in fifty years, and the best science shows the community suffering from sea level rise before that time, the policy will be ineffective. The method for normalizing perceived and actual risks must include a reasonable overall time horizon. Assuming the models and data stay constant, reason suggests each year that goes by with no change in community perception of risk will reduce the likelihood for community acceptance of the actual and evolving risks.

6 Conclusion

The history of public flood insurance in the United States has reinforced a preexisting path dependence emanating from historical roots in coastal development along with behavioral preferences for coastal living. In the case of coastal flood insurance, subsidies have fueled an expectation that coastal development and living is safe, both now and in the future. This makes sense when the premium paid for flood insurance is used as a proxy for risk perception: a subsidy in the premium lowers the perceived risk by making the risk avoidance 'affordable.'

In an era of climate induced sea level rise, the actual risks of coastal living are increasing. Storms are becoming more frequent, intense, and sustained. Further government subsidy of coastal living will likely only increase the disparities between actual coastal risks and how they are perceived, leading to a mismatch between the desire to communicate climate change risk and the incentives created for coastal development. Thus, the rational choice for governments is to begin to find ways for coastal communities to internalize the actual and evolving risks posed along the shore.

The US can begin to match its flood and disaster relief policies to current and evolving risks by moving towards an expansion of the National Flood Insurance Program that increases participants through mandatory insurance requirements, while also incrementally increasing premiums to reflect market rates. Existing path dependence will require increases in premiums to occur over a reasonable period of time not to exceed worst-case scenarios for sea level rise disasters in a given coastal community. At the heart of any public policy change will be the ability of government to recognize community perceptions of risk through path dependencies,

and then taking appropriate actions to ensure current policies move towards harmonizing perceived and actual risks. Overcoming these path dependencies will be critical in aiding the public to internalize the evolving risks of living along the coast and thus matching existing policies with the desire to properly communicate climate change risks.

As noted earlier in this article, the US Government is already moving towards reducing its subsidies for coastal flood insurance, although not as quickly as originally intended under the originally passed Biggert-Waters legislation in 2012. Focusing on coastal flood insurance subsidy reductions, future work should look closely at the impacts of premium adjustments on coastal real estate valuations as well as the overall demand intensity for coastal living. Reductions in coastal property valuation and demand for coastal living would be clear evidence that the actual current and emerging risks of climate change are being communicated to the public through updated policy structures.

7 Declaration of Conflict of Interest

The author declares there are no known conflicts of interest in publishing this manuscript.

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Istanbul's Vulnerability to Climate Change: An Urban Sectors' Based Assessment

Aysun Aygün and Tüzin Baycan

1 Introduction

It is a scientific fact that the climate is changing and human activities are accelerating the natural changes in the climate (International Panel on Climate Change 2001). Climate change will affect all urban regions, directly or indirectly which consequences vary according to the location of the area and its preparedness. Globally, the population living in cities passed 50% of the world population. Therefore, the primary places of the challenge of adapting to climate change are cities in developing world (Evans 2011). In order to retain viability and protect inhabitants, urban regions need to be prepared to adverse effects of climate change. Recent OECD paper states "Cities are part of the climate change problem, but they are also a key part of the solution" (Kamal-Chaoui and Robert 2009, p. 3). Awareness of the importance of preparedness leads the response efforts to be extended beyond mitigation, which include adaptation. While mitigation covers all the actions taken in order to reduce greenhouse gas emissions, adaptation includes any plan or action undertaken to reduce vulnerability and increase resiliency to the impacts of climate change (Foster 2006). The idea of managing vulnerability after the determination of vulnerabilities generates the first step of a long-term study. Unless cities have a clear understanding of the vulnerability to climate change, the measures may be meaningless and ineffective. Understanding who and what are vulnerable to the kinds of climate hazards and what makes them vulnerable is prior

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among all adaptation and mitigation strategies. Therefore, assessing vulnerability of cities to climate change becomes an important issue for developing resilience and adaptation strategies.

The awareness of the need of mitigation and adaptation to climate change to reduce adverse impacts has already increased globally. Climate change communication studies have contributed to raising awareness of public. Since the climate change impacts are understood to be inevitable, communication efforts have focused on the measures to deal with it (Nerlich et al. 2010). At that point, the media and the policy have important role on the public behavior (Nisbet 2010). However, the unpredictable nature of climate change impacts make communication difficult in terms of public and political concerns (Doyle 2007).

Turkey located in the Mediterranean basin, is the one of the most affected regions from climate change. The concept of climate change adaptation and mitigation has recently started to be discussed in Turkey (Pamukçu 2010). In recent years, the awareness has increased with the global concerns and the communication efforts of NGOs. However, Turkey still has a long path to the resilience and needs more communication studies not only about public behavioral awareness but also political concern. It needs both national and local strategies for more resilient structure especially for metropolitan cities with high population. Assessing vulnerability is the starting point for developing resilience and adaptation strategies. Once information about vulnerability is available, decisions for resilient community can be easily made and implementation can begin.

The motivation of this study is to fill the gap in starting development of more resilient system and to develop communication on climate change at political level. As the largest metropolitan city in Turkey Istanbul needs to develop its climate change adaptation and mitigation strategies with a guide that analyzing the vulnerabilities of the city. In the early stages of the recognition of climate-based vulnerabilities in Turkey, the leading studies are highly essential. This study is a leading study that reveals the local and national level vulnerabilities that based on urban sectors in Istanbul. The study offers a comprehensive perspective considering all vital sectors in Istanbul, compares the vulnerabilities, and highlights the path for further resilience development actions.

This study aims to investigate the vulnerability of 11 selected sectors to climate change including health, water resources, energy, transportation, agriculture, public safety, land use and development, materials, infrastructure, ecology and biodiversity and culture in Istanbul. These sectors are examined in 25 selected planning areas with regard to Istanbul's sectorial development strategies. Using the multi-dimensional methodology, the paper aims to develop a vulnerability index and to rank the sectors according to their index values. The results of the study highlight the rank from the most to the least vulnerable sectors to climate change in Istanbul. The next section describes the conceptual framework of the study. Section "3" focuses on the case study and first describes the sectors and planning areas that are taken into consideration, next explains the methodology that used for the assessment of vulnerability, and then evaluates the findings of the study for all

sectors and planning areas. The last section highlights the most vulnerable sectors in Istanbul.

2 Vulnerability: A Conceptual Framework

Vulnerability concept emerged when it is realized that a focus on the damaging effects alone was insufficient. The impacts of the perturbations on the people, ecosystems and places should be better understood for the responses. With the concept of vulnerability the ability of a system to attenuate the stress or cope with it became an important determinant of system response (Turner et al. 2003).

Table 1 Definitions of vulnerability in different contexts

Vulnerability in human science	"Vulnerability is the threat (to hazardous materials) to which people is exposed (including chemical agents and the ecological situation of the communities and their level emergency preparedness). Vulnerability is the risk context." (Gabor and Griffith 1980)
	"Vulnerability is operationally defined as the inability to take effective measures to insure against losses. When applied to individuals vulnerability is a consequence of the impossibility or improbability of effective mitigation and is a function of our ability to detect the hazards." (Bogard 1989)
Social vulnerability	"Social vulnerability is defined as a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards." (Cutter and Finch 2008)
	"The degree to which societies or socio-economic groups are affected by stresses and hazards, whether brought about by external forces or intrinsic factors - internal and external - that negatively impact the social cohesion of a country." (UNDP 2000)
Vulnerability to hazards	"Vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards of place (risk and mitigation) with the social profile of communities" (Cutter 1996, p. 532)
	"Vulnerability is the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (an extreme natural event or process)." (Wisner et al. 2004, p. 11)
Climate change and vulnerability	"Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." (IPCC 2007, p. 883)
	"Vulnerability is the susceptibility of a system to harm from climate change. Vulnerability is a function of a system's sensitivity to climate change and the capacity of that system to adapt to climate change" (ICLEI 2007)

There exist many definitions of vulnerability that differ according to the context (Table 1). The term vulnerability is used in human science, climate change impacts, socio-economic concept, etc. which have common points.

According to all definitions, vulnerability is related to the external impacts like natural hazards, risk or stresses. The degree susceptibility of the system, society or environment determines the vulnerability level (Fig. 1). The common points of the definitions present three elements in vulnerability; exposure, sensitivity and adaptive capacity. The exposure can be environmental, social, economical or governmental such as drought, conflict, extreme price fluctuations. Sensitivity of the system that exposed and its adaptive capacity are also determinants of the level of consequences (Bizikova et al. 2009). Adaptive capacity is about the ability to access to the resources that help to response the effects of exposures. Exposure is related to the areas geographical location that may have high risks. However, sensitivity and adaptive capacity have variations depend on country, community, social groups, time and nature.

Through climate change perspective, exposure is the nature and degree to which a system is exposed to significant climatic variations (IPCC 2001). Changes in exposure are usually explored through climate models that show how under certain assumptions climate variables can change in time for a given area. Sensitivity means the 'degree to which a system is affected, either adversely or beneficially, by climate-related stimuli' (IPCC 2001). This definition reveals that different regions and groups will respond to the same event differently. The third element of vulnerability according to the IPCC's definition is adaptive capacity—'the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences' (IPCC 2001). Adaptive capacity refers to 'the whole of capabilities, resources and institutions of a country or region to implement effective adaptation measure' (Bizikova et al. 2009).

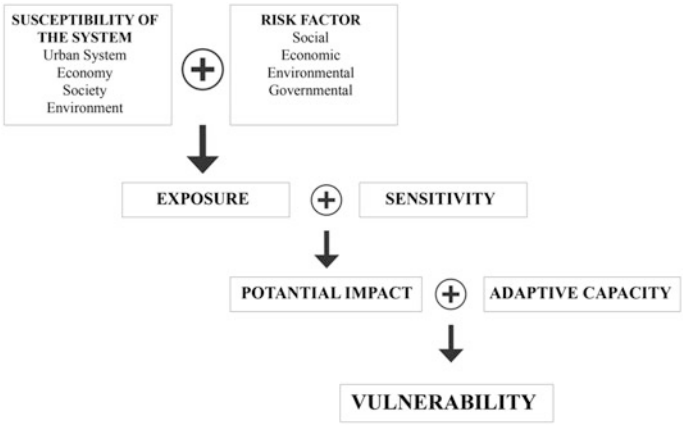

Fig. 1 The determinants of vulnerability

Vulnerability is a helping tool to increase resilience for both people and ecosystems (Bizikova et al. 2009). Focusing on the vulnerability reduction, understanding of projected exposures, and sensitivity of the system and adaptive capacity of it leads the community to the resilience.

3 Vulnerability Assessment of Urban Sectors to Climate Change in Istanbul

3.1 Prefatory Remarks

Istanbul has a special value with its history, natural resources and geographical location among world's metropolitan cities. It is not only the most populated metropolitan city with 14 million residents, but also the cultural, economic and touristic center of Turkey. Istanbul metropolitan region has become a mega-city, ranking 8 out of 78 OECD metropolitan regions in terms of population size and first for population growth since the mid-1990s. Istanbul used to concentrate about 5% of national population in 1950s whereas it is 20% today (OECD 2008). At the national level, the city is the most important center having the highest urban services (IMP 2009). Istanbul's GDP was $14,591 in 2008 while GDP was $9384 in Turkey. The city produces almost 27% of national GDP, 38% of total industrial output, more than 50% of services, and generates 40% of tax revenues (OECD 2008). Istanbul with its importance for the country plays a critical role in adaptation and mitigation to climate change effects. The high vulnerability of Istanbul causes an increase in the susceptibility of Turkey in terms of economic viability, social activities and sustainability. The city's position as an engine of the country requires a careful consideration of hazards. Increasing resilience of Istanbul to any adverse climate impact is essential not only for the city but also for Turkey. Therefore, the case study city of this research is Istanbul.

The aim of this study is to investigate the vulnerability levels of urban sectors to climate change impacts in Istanbul. In this study, the methodology defined by ICLEI (2007) in the publication of "Preparing for Climate Change: A Guidebook for Local, Regional and State Governments" has been deployed as a framework of vulnerability assessment. The results of this study highlight the most and the least vulnerable urban sectors in Istanbul to climate change based on the impacts of climate change, system sensitivity and adaptive capacity.

3.2 Data and Methodology

In this study ICLEI guidebook was deployed as a framework for vulnerability assessment. In order to assess vulnerability, 11 sectors and 25 planning areas were

identified (Table 2). Related planning areas cover major urban issues that are important for the viability of the city, likely to be affected by climate change. While determining planning areas, Istanbul's development plan and its sectorial development strategies were taken into consideration.

From relevant institutions data such as current programs and policies, climate change projections, future demographic and economic status were gathered. In addition, in-depth interviews were conducted with experts, representatives of companies and institutions, scientists and researchers. 54 interviews were conducted between April and December 2014. Interviews were carried out by a semi-structured questionnaire. The semi-structured questionnaire is aimed to learn the approaches of different sectors and variety of actors' approaches to climate change issue, their direct or indirect contributions to climate change adaptation and mitigation strategies, the awareness of the importance of the issue, different perspectives to the climate change issue. As an overall goal, it is aimed to evaluate the vulnerability and risk level of sectors from the perspective of relevant actors' attitude and strategy to the climate change issue.

Table 2 Selected sectors and planning areas

Sectors	Planning areas
Health	Air quality
	Heat
Water resources	Water quality
	Water supply
Energy	Energy production
	Energy demand
Transportation	Public transit
	Road and bridge maintenance
	Sea transit
Agriculture	Crop diversity
	Agricultural land maintenance
Public safety	Disaster response
	Urban risk areas
	Fire safety
Land use and development	Affordable housing
	Urban renewal
	Urban planning
	Social facilities
Materials	Waste collection and recycling
Infrastructure	Storm water management
	Sewage system
Ecology and biodiversity	Urban forest management
	Green spaces
	Biodiversity
Culture	Cultural and historical heritage

Table 3 The questions of semi-structured questionnaire

Questions for sensitivity analysis	Questions for adaptive capacity analysis
• What are the climate-based stresses the systems in that sector currently confront?	• To what extend do the current plans, policies or regulations consider the climate change impacts? Explain with examples
• How the current climate conditions affect the systems in that sector?	• To what extend are the current plans, policies or regulations sufficient for climate change impacts? (good, medium, bad) If more than one, explain for each
• How the climate conditions are projected to change?	• In order to struggle with climate change impacts, what kind of additional interventions, policies or regulations are needed?
• What are the expected climate-based future stresses the system will confront?	• Have the studies addressing climate change impacts started for the systems in that sector?
• How is the sensitivity of the system's natural or structural components to climate change?	• Is there any barrier to the adaptation climate change or struggle with it for the sector?
• How is the climate change expected to affect the system's natural and structural components? Which one of the expected impacts is the most important, why?	• What are the opportunities of the sector to adaptation to climate change and struggle with it?
• Is the system's current situation ready for the climate change? What is the sensitivity level of the sector?	• Is the system's current situation ready for the climate change? What is the adaptive capacity level of the sector?

Vulnerability assessment was conducted in two parts as defined in ICLEI Climate Change Guidebook, through a sensitivity analysis and an adaptive capacity analysis. The questions for the sensitivity and adaptive capacity analyses include Current and Expected Stresses to Systems, Known Climate Conditions Relevant to Systems, How Known Climate Conditions Currently Affect Systems, How Known Climate Conditions are Projected to Change, Projected Impacts of Changes to Systems, Projected Change in Stresses to Systems, Ability of the Systems to Accommodate Projected Impacts with Minimum Disruption or Costs, Barriers and Facilitators to Improving Resiliency. Semi-structured questionnaire (Table 3) was constructed on the basis of those questions addressed in ICLEI Climate Change Guidebook.

The final assignment of sensitivity and adaptive capacity levels was made by combining the answers of semi-structured questionnaire and the information gathered at the beginning of the study. Both sensitivity and adaptive capacity levels were assigned as high, medium or low according to the impact of climate change. A planning area that would experience great impact from climate change was rated as high sensitivity, while an area would have little or no impact was rated as low sensitivity. On the other hand, a planning area having the ability to absorb climate impacts well and few barriers to adopting was ranked as high capacity level

whereas, an area that does not have the ability to absorb climate impacts and faces restrictive barriers was ranked as low adaptive capacity.

Results of those two analyses—Sensitivity Analysis and Adaptive Capacity Analysis—were placed in an index to provide an overall vulnerability score. Sectors and planning areas were ranked considering their overall vulnerability score in order to determine the most and the least vulnerable areas.

Table 4 Sensitivity and adaptive capacity analysis for the planning area of health

Planning area	Sensitivity analysis	Adaptive capacity analysis
Air quality	**Stresses**: Allergies, asthma, respiratory system diseases, risk of skin cancer, skin diseases **Climate conditions**: Temperature, season length, humidity, airflow, rain **Climate effects**: Photochemical reaction on human body and dilution on atmospheric ozone layer **Climate projections**: Increase in temperatures and length of the hotter summer days, increase in atmospheric weather events **Impacts of changes**: Increase in allergies, respiratory diseases, asthma and risk of skin cancer. **Change in stresses**: Negative	**Ability of the systems to accommodate**: Air pollution is observed, measures are taken to decrease pollution, solutions are discussed and created for traffic based air pollutions **Barriers and facilitators**: Urbanization, urban heat island effect, lack of awareness
	Sensitivity score: Medium (2)	**Adaptive cap. score: Medium (2)**
Heat	**Stresses**: Long hot periods **Climate conditions**: Temperature, season length **Climate effects**: Decrease of the comfort level **Climate projections**: Increase in temperatures and length of the hotter summer days **Impacts of changes**: Increase in summer death and increase in the energy usage for cooling **Change in stresses**: Negative	**Ability of the systems to accommodate**: Contradiction between urbanization pattern and climate conditions, need for natural cooling methods **Barriers and facilitators**: Population growth, lack of open green spaces in the city center, urbanization, high air conditioner usage for cooling
	Sensitivity score: High (3)	**Adaptive cap. score: Low (3)**

3.3 Empirical Results

3.3.1 Health

The density of the settlements and the population are the main problems in Istanbul that cause a decrease in air quality and an increase in urban heat island effect (Table 4). Traffic jam especially at peak hours is another factor that decreases the air quality. The old settlements are lack of green and open spaces while existing green areas are under pressure of urban development.

Table 5 Sensitivity and adaptive capacity analysis for the planning area of water resources

Planning area	Sensitivity analysis	Adaptive capacity analysis
Water quality	**Stresses**: Pollution and urbanization pressure **Climate conditions**: Temperature, rain, floods, drought, humidity, sea level rise **Climate effects**: Waste water and waste material leakage, salinization, pollutants carriage because of storm and erosion **Climate projections**: Increase in temperatures and length of the hotter summer days, drought, more frequent and severe storm events, sea level rise **Impacts of changes**: Increase in pollution caused by weather events, salinization **Change in stresses**: Negative	**Ability of the systems to accommodate**: Quality of water is controlled regularly. New water treatment plants are constructed **Barriers and facilitators**: Investments for water refined before distribution, precautions to protect water basins, illegal settlements in the basin and being lack of waste water discharge system
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**
Water supply	**Stresses**: No advantages in terms of streams **Climate conditions**: Temperature, rain, drought **Climate effects**: Evaporation, decrease in the water level of reservoirs, drought and water scarcity **Climate projections**: Increase in temperatures, changes in precipitation, long arid periods **Impacts of changes**: Decrease in water levels in reservoirs, consumption of water sources **Change in stresses**: Negative	**Ability of the systems to accommodate**: There are many drinking water reservoirs and more are under construction **Barriers and facilitators**: Urbanization pressure, lack of water reuse systems (rain or waste water), increasing cost of water supply
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**

3.3.2 Water Resources

Istanbul does not have advantages in terms of water resources. Uncontrolled urbanization in Istanbul has created great pressure on water resources for a long time (Table 5). Illegal settlements within the boundaries of the water basins and over usage of underground water threatens the resources. The water is supplied from reservoirs in other cities around Istanbul. Increasing population and water demand might be a problem for water supply in the future.

Table 6 Sensitivity and adaptive capacity analysis for the planning area of energy

Planning area	Sensitivity analysis	Adaptive capacity analysis
Energy production	**Stresses**: Turkey can only produce 40% of its energy demand **Climate conditions**: Temperature **Climate effects**: In the winter the energy is needed for heating while in the summer for cooling. Renewable energies are directly affected by the climate conditions and events **Climate projections**: Increase in temperatures, hotter summer and warmer winter days, Urban Heat Island effect **Impacts of changes**: The need for heating energy is decreasing, the cooling energy is increasing, more energy consumption **Change in stresses**: Negative	**Ability of the systems to accommodate**: The investment to renewable energy increases **Barriers and facilitators**: Dependent to other countries and fossil fuel, no encouragement for the renewable energy by the government
	Sensitivity score: Medium (2)	**Adaptive cap. score: Low (3)**
Energy demand	**Stresses**: Population growth, increase in energy demand **Climate conditions**: Temperature **Climate effects**: In the winter the energy is needed for heating while in the summer for cooling **Climate projections**: Increase in temperatures, hotter summer and warmer winter days, Urban Heat Island effect **Impacts of changes**: Increasing energy demand, increase in energy cost **Change in stresses**: Negative	**Ability of the systems to accommodate**: Increasing energy cost, to sustain efficiency for the dwellings isolation and central heating systems are used is not enough **Barriers and facilitators**: The regulation for the energy efficiency is not carried into action, energy efficient building or green building, smart building is costly
	Sensitivity score: Medium (2)	**Adaptive cap. score: Medium (2)**

Table 7 Sensitivity and adaptive capacity analysis for the planning area of transportation

Planning area	Sensitivity analysis	Adaptive capacity analysis
Public transit	**Stresses**: Urban sprawl and population increase **Climate conditions**: Temperature, storm, flood, extreme weather events, icing **Climate effects**: Extreme weather events block some public transportation modes **Climate projections**: Increase in temperatures, more frequent and severe storms, increase in the number of icy days, more extreme weather events **Impacts of changes**: Traffic jam, unsufficient public transportation, cancelled trips **Change in stresses**: Negative	**Ability of the systems to accommodate**: Alternatives of public transportation prevent the failure of the system, the number of public transit vehicles and the frequency of run should be increased, sustainability of the transportation system is the main concern of policy makers **Barriers and facilitators**: The Transportation Department has the biggest budget at the Municipality, Master Plan focuses on developing public transportation
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**
Road and bridge maintenance	**Stresses**: Needs constant maintenance **Climate conditions**: Temperature, storm, flood, extreme weather events, icing **Climate effects**: Damages on the roads, cracks on asphalt, melting of asphalt, collapse **Climate projections**: Increase in temperatures, more frequent and severe storms, increase in the number of icy days, more extreme weather events **Impacts of changes**: Increase in the need of maintenance of roads and bridges, more frequent disruptions on the roads **Change in stresses**: Negative	**Ability of the systems to accommodate**: New systems are developed to observe meteorological conditions and to predict the possible effects, action teams are always ready for any problem **Barriers and facilitators**: There is no emergency action plan, roads and bridges are controlled regularly and any hazard is repaired, smart systems are used to warn citizens
	Sensitivity score: High (3)	**Adaptive cap. score: High (1)**
Sea transit	**Stresses**: The Bosporus is also used for freight shipment. **Climate conditions**: Precipitation, storm, fog **Climate effects**: Cancellation of trips, travel time and cost **Climate projections**: More frequent and severe precipitation, storms and fog, rising of sea level **Impacts of changes**: More cancellation of the trips, the increase of	**Ability of the systems to accommodate**: There are limited actions because of the direct effect of the weather conditions on the sector **Barriers and facilitators**: Smaller, faster and practical ferries are needed, however it is costly. The shipment through the Bosporus creates risk for vertical transportation.

(continued)

Table 7 (continued)

Planning area	Sensitivity analysis	Adaptive capacity analysis
	the sea level would increase the distance, increase in the cost of operation **Change in stresses**: Negative	
	Sensitivity score: High (3)	**Adaptive cap. score: Low (3)**

3.3.3 Energy

Energy supply is dependent to external resources and fossil fuel is the main production source in Turkey. Investment to renewable energy, especially to the wind is increasing. However, sufficient importance and incentives are not given to renewable energy investments by the government (Table 6).

3.3.4 Transportation

Sustainability of the transportation system is the main concern of the local authority as well as policy makers (Table 7). Strategies such as spreading rail system across the city and usage of natural gas for the buses are developed for the city. Transportation Master Plan developed by Istanbul Metropolitan Municipality focuses on spreading public transportation. New rail systems are under construction. In order to integrate different transportation modes, smart systems, transfer centers are developed. New systems are developed to observe meteorological conditions and to predict the possible effects.

3.3.5 Agriculture

The Ministry of Agriculture has already prepared the "Struggle Strategy and Action Plan for Agricultural Drought" for Marmara Region. Istanbul is not an agricultural city and agricultural lands are getting smaller. Pollution increases and rapid urbanization creates irreversible impacts on agricultural land (Table 8).

3.3.6 Public Safety

Istanbul has illegal settlements (slums) problem since the early stages of urbanization. Illegal settlements are mostly located in highly risky areas. In order to diminish the risk and control the settlement pattern, urban renewal is an advantageous implementation in those areas that is currently the prior strategy in the city.

Table 8 Sensitivity and adaptive capacity analysis for the planning area of agriculture

Planning area	Sensitivity analysis	Adaptive capacity analysis
Crop diversity	**Stresses**: Climate conditions, drought affects fertility **Climate conditions**: Precipitation **Climate effects**: The change in precipitation affects the fertility **Climate projections**: Less precipitation, drought **Impacts of changes**: Some crop types cannot adapt to the new climate conditions **Change in stresses**: Negative	**Ability of the systems to accommodate**: The action plan for drought has already prepared and crop diversity that is compatible with new climate condition is determined. Remote sensing systems to predict the fertility **Barriers and facilitators**: Istanbul is not an agricultural city and agricultural lands are getting smaller
	Sensitivity score: Medium (2)	**Adaptive cap. score: Medium (2)**
Agricultural Land Maintenance	**Stresses**: Urbanization, pollution, drought periods **Climate conditions**: Precipitation, drought, air quality **Climate effects**: Drought **Climate projections**: Less precipitation, longer drought periods **Impacts of changes**: Decrease of quality of the soil, fertility, more pollution, urban pressure **Change in stresses**: Negative	**Ability of the systems to accommodate**: The Ministry of Agriculture has already prepared the "Struggle Strategy and Action Plan for Agricultural Drought" **Barriers and facilitators**: Pollution, urbanization threat
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**

The expropriation is one of the important parts of risk diminishing plan for the Istanbul Metropolitan Municipality, however it is costly (Table 9).

3.3.7 Land Use and Development

The urbanization pattern of Istanbul is extended—urban sprawl—and complex with dense old city center, slums, illegal housing (Table 10). Most of the housings are unqualified in terms of energy efficiency and risk management. The risk could be reduced by urban renewal and the living conditions could be improved which is a prior strategy for the city. There are legal encouragements for the renewal that spreading the transformation all over the city. Old and dense high-rise settlements are lack of open and green spaces leading to urban heat island effect and air pollution. Although Istanbul Development Plan has not considered climate change yet as a priority concern, its development strategies contribute to sustainability.

Table 9 Sensitivity and adaptive capacity analysis for the planning area of public safety

Planning area	Sensitivity analysis	Adaptive capacity analysis
Disaster response	**Stresses**: Temperatures, storms and flooding **Climate conditions**: Temperature, precipitation, storm, flood **Climate effects**: Flooding, drought, storms are the serious risks for the city **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms and flooding, rising number of forest fires **Impacts of changes**: Serious damages to the city. The solution for the situation would be more difficult **Change in stresses**: Negative	**Ability of the systems to accommodate**: The prediction system is an important tool to intervene before the disaster happens **Barriers and facilitators**: The intervention strategies and disaster prediction is prepared for today's climate conditions. There is no plan for future considering climate change. The studies conducting today may not be sufficient for the future
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**
Urban risk areas	**Stresses**: Illegal and unplanned settlements where low income groups live **Climate conditions**: Temperature, precipitation, storm, flood **Climate effects**: settlements located on stream bed and valley, under risk of flooding **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms and flooding **Impacts of changes**: More frequent and severe weather events would cause deaths and losses. Flooding, unsufficient living conditions, health problems **Change in stresses**: Negative	**Ability of the systems to accommodate**: Urban renewal could be an advantage, ISKI determines the flooding areas and plans the stream reclamation **Barriers and facilitators**: Expropriation is costly, urban renewal can be a strategy for relocating risky settlements
	Sensitivity score: High (3)	**Adaptive cap. score: Low (3)**
Fire safety	**Stresses**: Forest fires, the fires caused by usage of coal **Climate conditions**: Temperature, drought **Climate effects**: Heat and drought cause fires **Climate projections**: Increase in temperatures, long arid periods **Impacts of changes**: Increase in the forest fire, no effect on residential fires **Change in stresses**: Negative	**Ability of the systems to accommodate**: Technology is used to improve intervention methods. The team can reach everywhere in Istanbul in 6 min. There are plans and sufficient equipment for any severe situations **Barriers and facilitators**: The intervention techniques are improving continuously using latest technological advancement. Need for more fire stations
	Sensitivity score: Medium (2)	**Adaptive cap. score: High (1)**

Table 10 Sensitivity and adaptive capacity analysis for the planning area of land use and development

Planning area	Sensitivity analysis	Adaptive capacity analysis
Affordable housing	**Stresses**: Many risky areas where settlements are developed illegally **Climate conditions**: Temperature, floods **Climate effects**: Unqualified settlements can highly be damaged by storms or floods which may cause deaths and loss of property **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme climate events **Impacts of changes**: More damage would occur because of severe weather events. More need for affordable housing **Change in stresses**: Negative	**Ability of the systems to accommodate**: TOKI contributes to production of affordable housing **Barriers and facilitators**: No smart systems, energy efficiency systems for residential areas because of being costly. Many slums that settled on the risky areas
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**
Urban renewal	**Stresses**: Over 2 million buildings, 25.000 buildings are under transformation **Climate conditions**: Temperature, floods, storms **Climate effects**: The risk could be reduced by urban renewal and the living conditions could be improved **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme events **Impacts of changes**: The living standards would decrease. More energy consumption **Change in stresses**: Negative	**Ability of the systems to accommodate**: Legal encouragements for urban renewal **Barriers and facilitators**: Reconstruct the buildings that could be endurable for the disasters. The smart systems and energy efficiency systems are only used for luxury houses as they are costly
	Sensitivity score: High (3)	**Adaptive cap. score: High (1)**
Urban planning	**Stresses**: Increasing population and housing demand, not yet considered climate change as a priority concern **Climate conditions**: Temperature, floods **Climate effects**: Illegal and unplanned housing development confronts flooding. Urban heat island effect and air pollution **Climate projections**: Increase in temperatures, more frequent and	**Ability of the systems to accommodate**: Master Plan contributes to sustainable development. Old central and unplanned dense settlements pose the biggest problem **Barriers and facilitators**: The plan is proposed for sustainable development however its implementation is problematic because of the high value of the land.

(continued)

Table 10 (continued)

Planning area	Sensitivity analysis	Adaptive capacity analysis
	severe precipitation, storms, and flood, more extreme events **Impacts of changes**: The city will need more climate change mitigation policies **Change in stresses**: Negative	Climate change is not the priority of the Metropolitan Planning Department
	Sensitivity score: Medium (2)	**Adaptive cap. score: Medium (2)**
Social facilities	**Stresses**: The old settlement areas are lack of social facilities, green areas per person is not sufficient **Climate conditions**: Temperature, floods, storms **Climate effects**: Increase in travel demand for long distances, air pollution and extreme heat **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme events **Impacts of changes**: Decrease in the quality of environment and life **Change in stresses**: Negative	**Ability of the systems to accommodate**: In the old and unplanned settlement areas it is difficult to solve the inadequate social facility problems. For the new development areas, plans consider the social facility necessity **Barriers and facilitators**: Urban renewal cannot change the settlement pattern and generate new open spaces. Expropriation is costly
	Sensitivity score: Medium (2)	**Adaptive cap. score: Low (3)**

Table 11 Sensitivity and adaptive capacity analysis for the planning area of materials

Planning area	Sensitivity analysis	Adaptive capacity analysis
Waste collection and recycling	**Stresses**: This system works efficiently **Climate conditions**: Temperature, floods, storms **Climate effects**: In the winter, some problems may occur in collecting the waste from districts. Floods, storms or erosion **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme events **Impacts of changes**: More disruption in collecting waste, harmful leakage to the underground water or spread of waste to the environment **Change in stresses**: Neutral	**Ability of the systems to accommodate**: Technological improvements in collecting and storing of waste. Regular controls **Barriers and facilitators**: Environmental aspects are taken into consideration not to harm environment. Infrastructure is designed to prevent any leakage and to collect the harmful methane gas. The technology enables to better protection of environment
	Sensitivity score: Low (1)	**Adaptive cap. score: Medium (2)**

3.3.8 Materials

The population of Istanbul—14 million—causes extreme amount of waste generation (Table 11). Collection and storage of waste materials create environmental problems especially when they are stored at open yards. However, improvements in technology have led to more sustainable collection, storage and recycling methods of materials.

3.3.9 Infrastructure

Increasing population and density of the city would be a problem in terms of infrastructure (Table 12). Increasing amount of impenetrable surfaces prevents the surface to absorb the water. While designing infrastructure, future climate conditions and population increase are underestimated.

Table 12 Sensitivity and adaptive capacity analysis for the planning area of infrastructure

Planning area	Sensitivity analysis	Adaptive capacity analysis
Storm water management	**Stresses**: Istanbul has separated infrastructure system **Climate conditions**: Floods, precipitation **Climate effects**: Over flows because of the inadequate size of the water pipeline **Climate projections**: More frequent and severe precipitation, storms, and flood, more extreme events **Impacts of changes**: More over flows **Change in stresses**: Negative	**Ability of the systems to accommodate**: The size of the pipelines should have determined according to the future precipitation projections. Impenetrable surfaces prevent the surface to absorption **Barriers and facilitators**: The size of the water pipelines is not adequate for the heavy rain. The cost of reconstructing and reuse of storm water
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**
Sewage system	**Stresses**: The waste water is directly discharged to the sea or streams in some districts **Climate conditions**: Floods, precipitation **Climate effects**: No effect **Climate projections**: More frequent and severe precipitation, storms, and flood, more extreme events **Impacts of changes**: Increasing densities cause the problem of insufficient sewage system **Change in stresses**: Neutral	**Ability of the systems to accommodate**: There are investments for new wastewater treatment plants **Barriers and facilitators**: Existing infrastructure would not be sufficient for more density and more population.
	Sensitivity score: Low (1)	**Adaptive cap. score: Medium (2)**

Table 13 Sensitivity and adaptive capacity analysis for the planning area of ecology and biodiversity

Planning area	Sensitivity analysis	Adaptive capacity analysis
Urban forest management	**Stresses**: Urban development **Climate conditions**: Temperatures, floods, droughts **Climate effects**: Trees' health, adverse weather conditions weaken the trees **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme events, long arid periods **Impacts of changes**: The stress on the forests would increase. **Change in stresses**: Negative	**Ability of the systems to accommodate**: The natural protection area border determines the development conditions in that area according to its protection level. However, the protection levels are questionable and changeable **Barriers and facilitators**: There is no strategy to strengthen the trees. The afforestation areas are away from existing forest areas and they are not efficiently organized
	Sensitivity score: Medium (2)	**Adaptive cap. score: Low (3)**
Green spaces	**Stresses**: The natural plants which could live in Istanbul's climate are chosen for the green areas **Climate conditions**: Temperatures, floods, droughts **Climate effects**: Trees' health, adverse weather conditions weaken the trees. Irrigation is important **Climate projections**: Increase in temperatures, more frequent and severe precipitation, storms, and flood, more extreme events, long arid periods **Impacts of changes**: The more storm and flooding damage on green space, budget of municipality. Problems for irrigation and maintenance of the plants **Change in stresses**: Negative	**Ability of the systems to accommodate**: Istanbul Metropolitan Municipality works regularly on determination of sick and deteriorated trees. The equipment and the personal are ready for any adverse event about green areas **Barriers and facilitators**: There is no preparation or strategies for future climate. However, slow climate change can be manageable
	Sensitivity score: Medium (2)	**Adaptive cap. score: Medium (2)**
Biodiversity	**Stresses**: Urbanization, hunting, over consumption of resources, pollution **Climate conditions**: Any change in climate conditions would affect the biodiversity and environment **Climate effects**: The certain impact of climate cannot be acknowledged. **Climate projections**: Increase in temperatures, more frequent and more extreme weather events, change in seasons and climate conditions **Impacts of changes**: Any change in climate condition will negatively affect the biodiversity **Change in stresses**: Negative	**Ability of the systems to accommodate**: In Istanbul Environmental Plan, ecology and biodiversity are taken into consideration, the important ecological lands are determined and protection for those areas is suggested **Barriers and facilitators**: Ecologically important habitats are already under pressure of urbanization. The resources are over consumed and those areas cannot be properly protected from external impacts. There is no study about biodiversity, endangered species and protection strategies
	Sensitivity score: **High (3)**	**Adaptive cap. score: Low (3)**

3.3.10 Ecology and Biodiversity

Istanbul has important natural protection areas around the city. The natural protection area border determines the development conditions in that area according to its protection level. However, the protection levels that are questionable and changeable create risk for those areas. Biodiversity is threatened by urbanization, hunting, over consumption of resources and pollution. There is no study on ecosystem and climate impact on biodiversity in that ecosystem (Table 13). Therefore, the certain impact of climate change cannot be acknowledged.

3.3.11 Culture

Istanbul has a rich cultural and historical heritage especially in Istanbul Historical Peninsula. The historical structures owned by public institutions are well managed and protected. However, those structures are open to any climate impact and there is a limited strategy to protect them from climate change effects (Table 14).

Table 14 Sensitivity and adaptive capacity analysis for the planning area of culture

Planning area	Sensitivity analysis	Adaptive capacity analysis
Cultural and historical heritage	**Stresses**: The historical buildings are directly affected by climate. Threat of sea level rise **Climate conditions**: Temperature, precipitation, sea level rise **Climate effects**: The buildings are open to climate destruction. **Climate projections**: Increase in temperatures, more frequent and severe storms, flooding and precipitation, rising of sea level **Impacts of changes**: More cracks on the building walls and more destruction. Some important structures, palaces are under risk of sea level rise and flooding **Change in stresses**: Negative	**Ability of the systems to accommodate**: There are 20.000 historical structures that are under protection in Istanbul Historical Peninsula. The public institutions work regularly for restoration of important buildings and maintenance of structures **Barriers and facilitators**: The historical buildings which are under the private ownership cannot be protected by local government and there is a limited thing to do. There is no encouragement to protect buildings under private ownership. There are too many buildings to be protected so the budget may not be sufficient
	Sensitivity score: High (3)	**Adaptive cap. score: Medium (2)**

Table 15 The sensitivity, adaptive capacity and vulnerability scores of all planning areas

Sectors	Planning areas	Sensitivity level	Adaptive capacity	Vulnerability level
Health	Air quality	Medium (2)	Medium (2)	Medium (4)
	Heat	High (3)	Low (3)	High (6)
Water resources	Water quality	High (3)	Medium (2)	High (5)
	Water supply	High (3)	Medium (2)	High (5)
Energy	Energy production	Medium (2)	Low (3)	High (5)
	Energy demand	Medium (2)	Medium (2)	Medium (4)
Transportation	Public transit	High (3)	Medium (2)	High (5)
	Road and bridge maintenance	High (3)	High (1)	Medium (4)
	Sea transit	High (3)	Low (3)	High (6)
Agriculture	Crop diversity	Medium (2)	Medium (2)	Medium (4)
	Agricultural land maintenance	High (3)	Medium (2)	High (5)
Public safety	Disaster response	High (3)	Medium (2)	High (5)
	Urban risk areas	High (3)	Low (3)	High (6)
	Fire safety	Medium (2)	High (1)	Low (3)
Land use and development	Affordable housing	Medium (2)	Medium (2)	Medium (4)
	Urban renewal	Medium (2)	High (1)	Low (3)
	Urban planning	Medium (2)	Medium (2)	Medium (4)
	Social facilities	Medium (2)	Low (3)	High (5)
Materials	Waste collection and recycling	Low (1)	Medium (2)	Low (3)
Infrastructure	Storm water management	High (3)	Medium (2)	High (5)
	Sewage system	Low (1)	Medium (2)	Low (3)
Ecology and biodiversity	Urban forest management	Medium (2)	Medium (2)	Medium (4)
	Green spaces	Medium (2)	Medium (2)	Medium (4)
	Biodiversity	High (3)	Low (3)	High (6)
Culture	Cultural and historical heritage	High (3)	Medium (2)	High (5)

3.4 Vulnerability Levels of All Sectors and Planning Areas

Vulnerable sectors can be defined as highly exposed to the climate conditions, under stress of climate and non-climate factors and low ability to absorb or adapt to the climate change impacts and new conditions. In Istanbul, the most vulnerable systems are heat, sea transit, urban risk areas, and biodiversity with the score of 6 can be seen in Table 15. For the improvements of those highly vulnerable areas, local government should make studies especially on urban development and urban structure. The other highly vulnerable system groups with score of 5 are; water quality, water supply, energy production, public transit, agricultural land maintenance, disaster response, social facilities, storm water management and cultural and historical heritage. The improvements in some of those systems such as energy production, agricultural land maintenance can be accomplished by a higher level governmental organization and regulations. Those problems are large-scale problems and legal encouragement and regulations are needed. However, the others are city level problems and can be improved by local government studies.

The systems that have medium vulnerability are; air quality, energy demand, road and bridge maintenance, crop diversity, affordable housing, urban planning, urban forest management, and green spaces.

The systems that have low vulnerability are; fire safety, urban renewal, waste collection and recycling, sewage system. Those systems have low vulnerability level because of their flexibility or technological improvements or having encouragements or less exposure to the climate conditions.

4 Concluding Remarks

Istanbul is a complex urban system with its sectors and planning areas. Vulnerability of planning areas to climate change is very important as the first step of a comprehensive study. In order to develop strategies for more resilient community, the starting point should be determined. This study is a guide for the further studies.

The vulnerability levels of planning areas can change over time with climate or non-climate effects. Some implementations may directly or indirectly affect the planning areas. Any disaster may occur can have serious impacts on the city system that decreases the resilience of the city. On the other hand, technological improvements, changing economic circumstances and changing demands which are non-climate dynamics that may have positive impacts on the systems resilience. Therefore, any situation that affects city system should be observed and the assessment should be updated considering those alterations. The advantage of the assessment is that, new data can easily be adapted to the analysis. Considering those changes, vulnerability levels of the planning areas may change. In time, reassessment is inevitable.

This study stands for the starting point in developing more resilient Istanbul, addressing the pathways for the further studies. It is a comprehensive study considering the vital city system components and actors that are active in development addressing the weaknesses, opportunities and giving clues for the further steps on resilience.

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Enhancing Intergenerational Communication Around Climate Change

Susan A. Brown and Raichael Lock

1 Introduction

This paper focuses on the question of how to promote intergenerational communication which evolves the understandings that children and adults need to identify and address climate change-related issues within and beyond their communities. This focus is of central importance to the Manchester Environmental Network (MEEN), a small UK voluntary sector organisation whose intergenerational project work with schools in the North West of the UK is dedicated to promoting in children and adults greater understandings of and capacities to address environmental issues.

The question emerges from conversations around MEEN's intergenerational climate change work between the authors of this paper, an academic at the University of Manchester (UoM), and the Director of MEEN, herself a Ph.D. student at the UoM. These conversations came about through broader collaborations between MEEN and academics at the University. MEEN has been involved in intergenerational work around climate change since 2012. Some of this work consists of children informing adults about climate change. The two authors, aware that the transmission of knowledge approach is not seen to lead to the 'transformative learning' needed to address climate change (see Sterling 2001, 2011) wished to explore whether this children-led, knowledge-based 'teaching' process' is an effective way of evolving children's and adults' understandings of climate change. Does it allow children and adults to share stories and experiences that relate,

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directly and indirectly, to climate change? Does it allow children's concerns around climate change to be listened to, a key objective in MEEN's intergenerational work? Is it conducive to exploratory conversations between children and adults that help them negotiate together feasible behavioural changes? Can the context of communication aid in those negotiations? This paper provides an initial exploration of these questions.

The paper is centred around three 'vignettes', evocative episodes based on the experiences and observations of MEEN in its Carbon Classroom project in a shopping centre in the North West. The vignettes have served to facilitate the two authors' communication with each other during the writing of this paper and our analyses. We draw on literature around intergenerational communication in school-related contexts to inform these analyses. We focus on notions relating to the status of children in intergenerational communication around climate change, on notions of 'cultural responsiveness' (Blanchet-Cohen and Reilly 2016) and on the notion of "reciprocally responsive' relations (Mannion 2016, p. 18) 'enmeshed' in place and community. We consider these notions as they relate specifically to climate change communication, thus contributing to an, as yet, small body of literature with that specific focus. We hope that the paper will serve as a starting point for conversations MEEN is keen to pursue with other organisations doing similar work.

The paper is divided into five sections. The first section explores perspectives on intergenerational communication in the literature with a following section on MEEN's activities and the Carbon Classroom project. The paper then sets out the three vignettes, providing an analysis of each of them. It goes on to draw these analyses together in overarching discussion of the vignettes as related to intergenerational communication around climate change, ending with reflections of how these explorations may inform MEEN's work.

2 Intergenerational Communication: Perspectives in the Literature

The literature informing this paper is drawn from diverse but interfacing fields, from human geographies, sustainability education, childhood and intergenerational studies and environmental studies. Taken together this literature reinforces Mannion's view that 'purposeful intergenerational contact' can act as a reminder of the contract between past, present and future generations in socio-environmental terms (2016, p. 3). It can conserve and generate local knowledge and insights needed to challenge and adapt to socio-environmental change in communities (Fernández-Llamazares et al. 2015). Children can inform understandings of climate-change related risks in their own terms, contributing to the diversity of understandings needed to tackle them (Tanner 2010).

Just as intergenerational communication can positively contribute to socio-environmental issues, so too can environmental learning projects engender greater intergenerational learning (Duvall and Zint 2007; Mannion 2012). They can mitigate against the 'generational niching' (Mannion 2016, p. 6) that hinders the multiply-informed communications needed to deal with climate change. Given the multiple levels on which climate change issues need to be addressed, such projects allow expanded scope for diverse contributions; they create opportunities for children and adults to find personally rewarding ways of connecting with such projects. In this process the status of contributors can be positively redefined (Duvaall and Zint 2007; Istead and Shapiro 2014).

Schools are seen as potentially useful places for developing this virtuous circle of intergenerational learning around socio-environmental issues (Mannion 2016; Mitchell et al. 2015; Percy-Smith and Burns 2013; Wyness 2013). Mannion sees schools as part of a broader nexus of sites of intergenerational learning, including the work-place, the family and community organisations (Mannion 2012). Such interlinked sites can 'help encourage better transfers of knowledge, values, and dispositions in order to address social issues …, and environmental and ecological issues' (Mannion 2016, p. 2). Schools, when viewed in this way, become potential 'agents of social change' (Duvall and Zint 2007, p. 20). They need to be permeable with school activities 'spilling out' into communities and community activities absorbed into schools (Smith 2007; Mannion and Adey 2011; Gruenewald 2003a, b). This has implications for the roles of children and adults both within and beyond schools. Both children and adults are recast as learners engaged in absorbing and sharing knowledge, values and dispositions' across interconnected sites of learning.

While the notion of children as absorbers of knowledge still underpins many educational systems, the idea of them imparting knowledge to adults is less culturally familiar in educational contexts. The tendency to 'replicate deeply structured patterns of behaviour' (Taft 2014, p. 460) where adults impart knowledge to children who then absorb that knowledge is a substantial impediment to such a dynamic, one encoded in many structures of learning. Intergenerational projects that do seek to give children greater 'voice' can be tokenistic and adult dominated. Children can feel that they are not listened to by adults, or that their contributions are drowned out or ignored (Grover 2004; Taft 2014). Adults can overly protect children and craft agendas for them (Liebel 2007) thus removing the agency they profess to be giving children.

The focus on 'children's voice' has been critiqued in some literature with some writers arguing that there is no such thing as an unmediated, authentic child's voice (e.g. Wyness 2013). Children's voices are always mediated by their experiences with adults and places. In seeking to challenge these deeply structured patterns intergenerational projects can marginalise adults to the detriment of intergenerational communications (Wyness 2013).

Such deeply structured patterns of behaviour can inhibit 'reciprocally responsive' intergenerational communication (Mannion 2016; Taft 2014; Wyness 2013). Such communications are dialogical. They expand opportunities for greater intergenerational communication through, amongst other things, recognition of, and

responses to the cultural and structural inequalities which constrain the roles of children. They evolve in response to the specificities and challenges of place/community. In so doing they can address issues within those communities in contextually relevant ways (Mannion and Adey 2011; Mannion 2016). They recognise and draw on the diverse qualities that individual children and adults bring to communication. This recognition of diverse, individual voices creates the space for culturally responsive communication, sensitive to 'alternate ways of knowing and seeing the world' (Blanchet-Cohen and Reilly 2016). It can lead people 'out of their comfort zones and prompt… reassessment of long-held assumptions' (Wyness 2015, p. 290). It can also challenge the generational stereotyping privileging interpersonal communication over stereotyped notions of intergenerational communication. In doing these things, reciprocally responsive intergenerational communications can be seen as facilitating transformative learning, that is to say learning that brings about 'a qualitative shift in perception and meaning making on the part of the learner in a particular learning experience such that the learner questions or reframes his/her assumptions or habits of thought' (Sterling 2011, p. 19).

Finding ways of facilitating reciprocally responsive intergenerational communication is a challenge of particular relevance to climate change. Anthropogenic climate change is a novel phenomenon which humans are ill-versed in tackling. The certitude that climate change is happening is not matched by conclusive understandings of how it will manifest itself, the extremes of those manifestations and how and to what degree it needs to be tackled. Developing understandings of how to tackle it will require evolving modes of communication where people continually develop and adapt the knowledge, skills and dispositions to mitigate (by reducing emissions) and adapt to it. Children, as significant stake holders in responding to climate change need to be involved in these communications.

The Manchester Environmental Educational Network is working to facilitate such evolving modes of communication. While it has an emerging sense of the potential benefits of reciprocally responsive intergenerational communications in climate change terms it is still exploring how to facilitate that communication, aware, as it is, of the 'falsely optimistic understandings of the ease of intergenerational partnerships' (Taft 2014).

3 Manchester Environmental Education Network and the Carbon Classroom Project

3.1 Contextualizing the Carbon Classroom Project

MEEN has organised a range of intergenerational projects with schools and the communities in which they are located. MEEN's intergenerational activities have included planting Peace Groves in honour of Wangari Maathai and an

environmental heritage project focussing on East Manchester's industrial history. MEEN's involvement in Carbon Literacy projects are explicitly intergenerational and focused on 'helping [children's] voices be heard on climate change' (Carbon literacy for Schools, n.d.). These include the delivery by children of a carbon classroom at the Manchester Museum as a part of Manchester's Climate Control exhibition (2016), a project organised in partnership with a cathedral in the North West (2014) and a carbon literacy project within schools and their local communities (2012/2013). The latter project inspired activities seen as appropriate to the school community, their needs and priorities' (Carbon literacy for Schools, n.d.). For example the children in one school organised a 'Switch-Off Fortnight' asking teachers, staff and parents to be involved, and ran an after school event inviting parents to engage in finding ways of saving energy in the home.

MEEN's Carbon Classroom activities were set up in conjunction with 'Cooler' a Manchester based 'Community Interest Project that delivers projects and advocacy to create a low carbon future' and with the Carbon Literacy (CL) project, founded by Cooler. The CL project works with individuals to both develop their carbon literacy and to help the individuals have a 'cascade effect' on a wider audience. MEEN's carbon literacy activities also connect to 'Eco Schools', a global programme helping children make positive environmental changes. The Eco Schools programme uses a 'simple seven-step process'. This begins with the formation of eco teams comprising children and an adult support and a pupil-led Eco-Committee and ends with the institution of an Eco-code created by pupils and instituted by the school. The Eco Schools intergenerational focus is explicitly related to 'Personal, Social and Emotional' development.

3.2 The Carbon Classroom Shopping Centre Project

The MEEN Carbon Classroom projects, which took place in a shopping centre in 2013 and 2015, are the focus of the vignettes in this paper. These projects have been chosen because of the range of 'evocative episodes' that emerged from them.

The activities in the shopping centre ran alongside other participatory Cooler projects communicating on climate change. Altogether seventeen groups of primary and secondary schools from the North West were involved. The schools teach children from diverse cultural backgrounds including first and second generation immigrants.

In the build up to this and the other carbon literacy projects, MEEN ran a variety of introductory sessions in schools with 'Eco teams', beginning with what the children already knew. The understanding of the basic science around climate change grew from that initial sharing and built on curriculum links relating to, for example, the formation of fossil fuels and the exchange of gases in plants. There were also interactive sessions such as the modelling of the release of CO_2 into the atmosphere and forming a blanket round the earth: this was represented by pupils adding layers of clothing onto a volunteer 'human earth' as they described the

different kinds of things they do each day that use energy. The layers were then removed to help the earth cool by each pupil stating how they could use less or different energy sources.

Once facets of the basic science were covered children were introduced to a number of activities to help them deepen their understanding of climate change. These activities were introduced as teaching tools the children then used in the Carbon Classroom to help others learn about the issues.

Once they had practised their chosen activities with each other, the children ran a small event inviting adults such as school staff or family members to trial the activities and give them feedback. While working with adults the children already knew was useful as a preparatory activity, they also needed to be prepared for approaching the general public. MEEN ran a session with each group to consider how to talk to the public, covering issues like 'people being rude' or 'asking difficult questions'.

The Carbon Classrooms comprised tables and chairs with the quiz activities of varying types laid out on the tables (see Fig. 1). Children approached people in the near vicinity of the Carbon Classroom inviting them to talk about climate change and learn more by 'entering' the classroom. The classroom consisted of a range of quizzes, including matching activities with the use of flash cards. Children used pictures in particular, to prompt adult thinking around knowledge of climate change and how it can be mitigated.

Fig. 1 Carbon Classroom layout. *Photo* Author's own

4 The Carbon Classroom Vignettes

The vignettes below derive from the observations of the MEEN Director as the episodes described in the vignettes took place. They are also based on informal chats and feedback sessions with children shortly after the episodes and on oral recorded comments (Vignette One).

4.1 Vignette One: The Community Police Officers

> Two boys, aged between eight and ten, approached two young, male policing community officers as they patrolled the shopping centre asking them to participate in the Carbon Classroom. The boys asked the officers if they had time to learn about climate change and were surprised and keen when they agreed to participate.
>
> The boys led the officers through the issues around climate change using cards and prompts but were also talking to them in some depth. When asked about the interaction afterwards one of the boys was very excited that the officers had bothered to sit with them and take the time to talk. He was surprised they didn't know that much about it and very pleased to have been able to inform them.
>
> One of the boys described this exchange as follows:
>
> We got a few people in the classroom including the police officers. That was good because they have a bigger role in the world. Instead of the community just doing it the police will get it out into the world.

The carbon classroom activities, situated in the shopping centre created opportunities for children to 'select' the people with whom they wish to engage, gauging the level of approachability of individuals (children encountered adults who declined to engage). The two boys were surprised that the officers agreed to take the time to talk to them because of their role as 'authority' figures, as the boys perceived it. Their keenness to engage with the officers may stem from that perception, as may the surprise of one of the boys that the officers didn't know much about climate change. The boy's assumption that police officers would have understandings of this because of their role perhaps throws light on expectations of what adults in authority ought to know about climate change.

The officers' evident willingness to listen and engage in conversation gave the boys opportunities to reflect on their own status as competent communicators and the relative extent and value of their knowledge. It offered them the chance to see the officers not as all-knowing authority figures but as personable and flawed humans. In turn the officers may have appreciated the opportunities to fulfil a key aspect of their role which is to interact with the public. Their willingness to engage interpersonally with the boys may derive from their inter-personal officer training and the focus on 'active listening' skills. Whatever was informing their engagement, their willingness to listen and engage had positive effects on the boys, raising their confidence and sense of agency.

The assertion by one of the boys that the police officers have 'a bigger role in the world' and may, therefore 'be able to get it [climate change] out into the World' indicates he sees authority figures in a primary position to convey messages of climate change and, consequently, as important people to engage with on climate change. The police officers come higher in the boy's imagined hierarchy of influence than does the 'community' to which the boy does not ascribe the capacities to get the message out beyond the community. The phrase 'we got a few people in the classroom including the police officers' suggests pride in the boys' achievement of successfully engaging individuals who play significant community roles. The boy positions his communications with the officers as valuable because of the potentially significant cascade effect it might trigger.

4.2 Vignette Two: The 'VIP'

> The Carbon Classroom had a visit from a few VIPs. One of them sat with the children to do an activity and talk to them about climate change. A child then asked her whether she would make a pledge to do something to help stop climate change. The VIP said she would take the children's message back to her government department and make sure they did everything they could to stop the problem. But the child didn't feel his question had been answered properly and said, "No, I mean what will you do?" The VIP told him she had already answered the question. But the child persisted, "But I want to know what you will do to help." The answer was not forthcoming and the conversation moved on.

The boy's (aged about 9) response to the VIP in this vignette indicates he views climate change in terms of individual responsibility, and concrete actions (the 'doing' rather than the talking'). Children's expectations of commitment to concrete actions have been noted in a number of publications around environmental issues/climate change (see for example: UNICEF 2007, p. 3; Blanchet-Cohen et al. 2003). The boy obviously felt the VIP's assurances that she would ensure the government department did all they could to stop the problem was insufficient as a pledge. He had been talking with the VIP about concrete actions that she could do herself (driving less etc.). The VIP's response is couched in different terms, i.e. taking the message (in her professional capacity) to the government department, and engaging in some unspecified way with climate change. This response fell short of the specificity in commitment to individual action that the boy saw as requisite to a proper climate-change pledge. The boy's insistence may link to the focus on individual responsibility both in MEEN's preparatory activities with the children and in the games and quizzes with which they engaged the adults. In this view, action against climate change needs to start with 'self'.

The VIP had been invited to the Carbon Classroom by Cooler (an NGO promoting Carbon Literacy,) in her capacity as a government representative to experience the project first hand. She may have felt she needed to respond in that professional capacity and speak on behalf of the government department. The boy however, was more interested in engaging with her on an interpersonal level.

Arguably, the VIP lost an opportunity to speak to the boy in the same interpersonal terms, thereby showing the boy that she was willing to lead through her own example. Even with explicit prompting from the boy, she was unable either to discern the most appropriate 'voice' to use with the boy or was disinclined to do so.

4.3 Vignette Three: A Matter of Interpretation

> A woman approached the Carbon Classroom interested to see what the children were doing but started to walk away when she realised she needed to speak English to engage in conversation. However, the girl trying to talk to her understood a few words she had spoken and called on a friend who was fluent in the language to lead the discussion instead.
>
> The girl, aged around 13, reported back that she had enjoyed being able to act both as an interpreter and as someone able to talk confidently about climate change.

The vignette is illustrative of the multicultural aspect of the Carbon Classroom project given the diverse cultural backgrounds of the children and the multicultural nature of Manchester. The girl who initially spoke to the woman recognised—perhaps thanks to exposure to the language in the school environment—the language the woman was speaking and that her friend spoke the same language and could act as interpreter. Her resourcefulness related, at least in part, to her recognition of the cultural resources available in the school community.

The girl who acted as a converser and interpreter, may have had her confidence boosted by her capacities to communicate information on climate change in more than one language. The role of children as intermediaries or bridgers between school and family contexts (and interpreters and translators in families where parents speak little English) is discussed in literature on intergenerational, environmental projects (see for example Blanchet-Cohen and Reilly 2013, 2016). Such a role can positively shape 'children's feelings of self-efficacy and agency' (Blanchet-Cohen and Reilly 2016, p. 17). However, it might, as one of the teachers interviewed by Blanchet-Cohen and Reilly argued, reduce children's roles simply to that of translator without the scope for creative expression beyond that translating role (p. 19). This is not the case for the Vignette discussed here where the girl acted both as an interpreter and creative communicator. Other episodes during the carbon classroom suggest that children communicating in different languages and cultural contexts can draw on their experiences in ways that creatively inform their participation. This is the case, for example, with a girl who had just come back from planting trees to "keep out the desert" with her grandmother in Malawi. The connection the girl was able to make between the work she did with her grandmother and the carbon classroom had the effect of significantly reducing her shyness to the surprise of her teacher who judged her to be overawed by the carbon classroom event.

5 Interpreting the Vignettes

Our explorations of the literature and analyses of the vignettes have gone some way to helping us gain a sense of the type of communications MEEN might beneficially promote. In relation to MEEN's aim of getting children's voices heard on climate change we find the notion of reciprocally responsive intergenerational communication particularly compelling and consonant with the development of communications, knowledge and skills around climate change.

We see Vignettes One and Three as demonstrating some of the generative qualities of reciprocally responsive communication. In both cases the children's sense of self-efficacy and agency as communicators on climate change was bolstered, and their status as effective communicators positively reinforced. In Vignette One this links to the evident engagement of the Policing Community Officers. In Vignette Three it links to the children's awareness that cultural and linguistic knowledge constituted a rich resource for communication around climate change.

We are struck by the ways in which cultural diversity can create opportunities for expanded communication around climate change. Holding the carbon classroom in a public space such as a shopping centre allows extended scope for such communication. This scope was created, in part, thanks to the selection of the shopping centre as a venue for the carbon classroom. The potential for such serendipitous intercultural encounters is greater in public places where children can choose for themselves with whom to engage. A project in a more 'controlled' space and informed by the perceived need to protect children (Liebel 2007) reduces the possibilities for such encounters. These encounters offer children greater opportunities to find the 'voice' that best responds to the encounter. As with adults, children can draw on their culturally-complex and culturally-unique identities (Singer 1998) to communicate on climate change. This capacity challenges stereotyped assumptions about how children converse with adults and the perceived need to surface the unmediated, authentic child's voice (Mannion and Adey 2011; Mannion 2016; Wyness 2013; Taft 2014). These assumptions are at odds with children's multi-voiced repertoires and their capacities to draw appropriately and sensitively on those voices. The more opportunities children have to rehearse these voices, whether through the rehearsal of one's own voice(s) or through engagement with those of other individuals—the greater the opportunities for rich conversation around climate change and for re-assessing long-held assumptions. Such re-assessment is crucial to formulating responses to climate-change.

The dynamics in Vignette Two are less successful. However we interpret the VIP's responses: e.g. as a misreading of the exchange, or an incapacity or refusal to speak to the boy on his own terms, her response led to a breakdown in communication. She had the latitude to draw on her own multi-voiced repertoire to speak to the boy in the terms with which he had engaged her. This could have been a potentially important exchange with opportunities for the VIP to make a solid link between her own actions to reduce her carbon emissions and her professional work. It could have helped the boy see the possibilities for impact on climate change that a

government department can have. As the boy in Vignette One understood, courses of action on climate change can include communicating with people in authority who are able, in that capacity, to get the message out. This expanded understanding of the varied routes into action on climate change sits well with the aims of Carbon Literacy project, with whom MEEN partners to achieve a 'cascade effect'.

Our analysis of the issues in Vignette Two have occasioned us to return to our literature-informed understandings of reciprocally responsive communication. The children in the project are cast as knowledgeable informants and the adults as learners. This coheres with the view that children can play rich roles in informing understandings of socio-environmental issues. However, in the carbon classroom the dynamic tends to be unidirectional, given the quiz-like, transmissive teaching activities, with the children imparting information to adults. The opportunities for reciprocal, interpersonal conversations, were limited. As some of the literature around intergenerational environmental projects indicates, children can bring new knowledge to environmental issues that adults may not possess (e.g. Blanchet-Cohen and Reilly 2016; Damerell et al. 2013; Istead and Shapiro 2014; Tanner 2010; Vaughan et al. 2003). However, the notion that knowledge alone can lead to understandings of how to deal with the complex issue of climate change is challenged in literature on Sustainability education (Percy-Smith and Burns 2013; Sterling 2001). A rich understanding of the shifting, complexities of climate change, particularly as they relate to social systems and human behaviours, comes through reciprocal, interpersonal conversation. The carbon classroom activities did indicate a lack of knowledge around climate change among many adults as was the case with the Policing Community Officers. However, the opportunities for adults to find an appropriate interpersonal 'voice'—as may have been the case with Vignette Two—and share knowledge and stories in ways they felt related to the points made by children were limited. This, in turn may have limited the scope for developing both the children and adults understandings. There were other episodes that MEEN might have drawn on to illustrate a more reciprocal conversation; a woman telling the children about growing and eating her own food; a young man describing how he had given up his car; but the basic premise that the children are teaching, for all its other benefits, could act as a limiter to more in-depth conversations that would enrich understandings of climate change.

We have been prompted, through our analyses, to consider the role of 'place' in respect of the carbon classroom. Reciprocally responsive communication evolves in response to the specificities and challenges of place, and can, through such communications, address issues within those places in contextually relevant ways. The incongruity between a shopping arcade selling the consumer goods that link to carbon emissions and an intergenerational project focussing on climate change may have been noted by children and adults participants. The potential for 'de-centring' acquired consumer behaviours through intergenerational communications around their repercussions in climate-change terms are considerable. The shopping centre as a site for prompting discussion about climate change was not explicitly focussed on in MEEN's activities although many of the prompts used referenced the carbon footprint of items such as a pair of jeans or a cup of tea which could be purchased

on site. One critical occurrence which raised this debate involved a few children from one of the high schools wanting to have burgers for lunch. The ensuing discussion between peers generated some intense debate over what constitutes a sustainable meal, with the internal controversy creating an awareness with some of the pupils of the need to practice what you teach. Less 'teacherly' activities with more opportunities for reciprocal dialogue may have allowed such awarenesses to be surfaced and considered by both children and adults.

6 Concluding Discussion

In this paper we have tried to formulate a response to the question of how to promote intergenerational communications which evolve understandings that children and adults need to address climate change-related issues.

Our explorations have given us insights into the opportunities the carbon classroom can create for 'culturally responsive' communications (Blanchet-Cohen and Reilly 2013, 2016) and the 'multi-voiced repertoires' that children can bring to such communications. The understanding of these multi-voiced repertoires allows us to move beyond notions of the unmediated, authentic voice of the child that needs to be 'heard' in the climate change debate. Rather it moves us towards an understandings of children as culturally complicated and culturally unique, capable of drawing on their multi-voiced repertoires to usefully influence communications around climate change. It gives conceptual insights into MEEN's observations of children as competent communicators around climate change.

This same insights raise questions as to why and how the multi-voiced repertoire of adults (e.g. their professional and personal voices) can be further integrated into activities such as the carbon classroom. Casting children in the role of 'teachers' around climate change certainly has its uses in helping adults understand basic aspects of climate change and helping them understand the concerns of children. It is also useful in building children's communicative competence, as the analysis of the vignettes suggest. However, it creates few opportunities for reciprocal, exploratory conversations where children and adults draw on their intergenerational and cultural diversity as a means of enriching their understandings of climate change, how it affects their own lives and communities, and how to respond to it, in the light of these understandings. Their existing and emerging life experiences, understandings of local communities, knowledge and expertise can all feed into the rich, multi-faceted conversations that build complex understandings of climate change. These things are difficult to do in the relatively short time that children and adults have in the carbon classroom. The onus would fall on children to appreciate and draw out that diversity, whereas reciprocal communications should involve both children and adults in negotiating ways of doing so. This said, there may be ways of promoting such communications in the carbon classroom. The quiz activities could include explicit prompts for conversation, where children and adults assess together what they themselves can/are prepared to modify in their own lives

in the light of evidence around climate change. It might involve an activity related to what a shopping centre might sell if the shops and customers were acting to mitigate climate change. Such activities would link intergenerational communications to the specificities of place—drawing attention to the connections between habituated consumer activities and climate change, and drawing on the experiences, stories and problem solving capacities of children and adults in equal measure.

Our insights are constrained by a lack of rich data relating to adult perceptions of the exchanges described in the vignettes above. These would have thrown light on the adult's reactions to engaging with the children, how they felt they responded to the children and how their encounters impacted, or not, on their thinking around climate change. This constitutes a limitation in this paper. It does, however, point to opportunities for deepening insights in future research.

Notwithstanding these limitations, our insights have brought us to the initial conclusion that the children-led, knowledge-based approaches the carbon classroom uses provides children with valuable opportunities to communicate on climate change with adults and to build confidence in their communicative capacities. It may also help adults see children as competent communicators around climate change and challenge stereotyped notions they may have around the ways children communicate. The carbon classroom, however, needs to build in opportunities for reciprocally responsive intergenerational communication. We see it as important to deepening understandings of the nature of and how to address climate change. We relate such communication to transformative learning around climate change, the learning which leads to a qualitative shift in perception For intergenerational communication to play a powerful role in addressing climate change this is what we now consider is needed and what MEEN should work towards.

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