WIREs CLIMATE CHANGE

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Article title: Communicating Adaptation to Climate Change: The Art and Science of Public Engagement when Climate Change Comes Home

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Abstract

This article synthesizes relevant literature and examples from practice to examine what is known to date about communicating climate change adaptation. It explores the language used to discuss adaptation, what is known about resonant frames, drawing on adaptation discourses in policy, practice and the media. Identifying trends and widely applicable insights is made challenging not only by the variety of words used to speak of adaptation, but by the fact that "adaptation" language is often not used at all. A broad literature on perceptions and experiences of climate change impacts and how these experiences affect people's valuations and emotional responses to climate change offers crucial insights to the challenges and opportunities in communicating adaptation. It reveals much about people's interest in and acceptability and knowledge of adaptation, about preferred timing and who is thought to be responsible for enacting adaptive actions. Insights from the literature on place attachment and place identity are of particular relevance to public engagement on adaptation as it goes a long way toward explaining the quality of the adaptation debate to date while offering promising opportunities for dialogue. Suggestions for improved adaptation communication practice and critical research gaps are offered.

Introduction

It has never been easy to communicate climate change. Now, as climate change becomes more than an abstract matter of science, but lived reality instead, it is a good time to ask whether communicating about how we respond to these unfolding impacts will be any easier. As humanity increasingly experiences the troubling consequences of anthropogenic climate change, what is known to date about how to communicate these impacts and "adaptation" to them? What do trial-and-error attempts and available research teach us?

This Focus Article attempts to synthesize a range of relevant insights with the goal of informing both communication research and practice. It rests on several premises. First, there is a rapidly growing need to communicate impacts and adaptation given the unfolding climate realities across the globe, yet communications research specifically focused on adaptation is still in the early stages. One indication of this need is that communication research and related training was identified as the second most frequently mentioned need in 27 U.S. federal agency adaptation plans (noted by 24 out of 27 agencies[1]). This suggests communicators involved in adaptation efforts are equipped with little guidance at present, making themselves vulnerable to lost opportunities at best and, at worst, easily failed and socially costly attempts when time, money and trust are scarce.

A second premise is the frequently encountered disconnect between science and international policy circles on the one hand, and decision-makers and managers on the ground on the other. While the former groups customarily distinguish the two basic policy options "adaptation" and "mitigation" (following frequently cited IPCC definitions), there is some evidence that this distinction is unpractical and cumbersome for the latter. This raises critical questions about how best to "translate" between science and high-level policy discourses and those occurring where climate change impacts are felt and responses are being implemented directly. It also foregrounds questions of how to talk about "adaptation" and how to link or integrate it with mitigation and other policy goals.

Third, there is good reason to believe that there are both challenges and opportunities in communicating adaptation, some empirically substantiated, others still speculative. For example, the ghost of Al Gore's famous dismissal of adaptation in 1989 as a 'lazy' cop-out on fighting the causes of climate change[2, 3] still haunts many today: talking about adaptation is frequently taken to indicate a concession of defeat on mitigation, or at least as creating competition or distraction from pursuing emissions reduction goals[4]. For others, the trouble with talking about adaptation is that it rings of social Darwinism[5], of high school biology slogans like "adapt or die" or "survival of the fittest"[6], and – contrary to the difficult and ideally pro-active adaptation work ahead – of passivity and giving up. Particularly for those skeptical of climate change, adaptation only brings local costs but uncertain or much delayed benefits. Others claim just the opposite: it should be easier to communicate adaptation because climate change is finally "real", local and tangible – all the things it was not when it was discussed as something happening globally "in a hundred years from now." To them, adaptive responses are visible and beneficial locally. Meanwhile, some believe – with hope more than empirical evidence – that talking

about adaptation rids climate communication of ideological baggage, because it addresses common local interests and occurs far away from the big media and policy arenas where discourses are trapped in polarized camps. Finally, communicating adaptation is thought to be easier than communicating the science of climate change or mitigation policies because it offers some immediate co-benefits, i.e. opportunities to do what should or will be done regardless – disaster risk management, urban renewal, conservation, innovation, or economic development. And for some, adaptation is neither easier nor harder to talk about; they don't see the point of talking about it at all, certainly not yet, and not in highly developed nations like the U.S. or Canada because climate change is thought to be mostly a threat to poor nations who don't have the resources and capacity to respond.

All these claims and assumptions beg to be empirically tested, and this review paper will explore which can be substantiated at this time, which constitute wishful thinking, and which require further research.

The questions this article tries to answer then include the following:

- What – if anything – is unique about communicating adaptation?
- What do we know about how to communicate adaptation successfully?
- Given the scientific (and policy) distinctions between mitigation and adaptation, is it useful to communicate differently / separately about these? And how can we translate between high-level and local discourses?
- What are fruitful areas of further research and how can the results be rapidly transitioned into communication practice?

*Approach to this Revie*w

This review is based on a synthesis of the available literature on communicating climate change impacts and adaptation. While this synthesis cannot claim completeness or comprehensiveness, it does attempt to touch on key aspects of communicating adaptation. A number of pathways were combined to identify the relevant literature. Firstly, a Web of Science (WoS) search was conducted using the truncated search terms "adapt*", "climat*", "change*", "impact*" and "communicat*". The results were screened to be about communicating adaptation. Because the resulting 31 articles clearly do not fully capture the relevant and available literature, the WoS search was supplemented, secondly, with a subjective collection of relevant peer-reviewed articles and book chapters and, thirdly, with a range of practice-sourced reports such as media reviews, project reports, survey studies, adaptation planning documents and so on. The combined substantial body of literature from many disciplines is thought to provide not a complete, but a thorough compilation of work that adequately reflects the current state of art and science on how to communicate climate change adaptation. Supplementary Material 1 explains the search pathways and offers a detailed justification.

Article Overview

The section *What Shall We Call This Thing Called 'Adaptation'?* begins the exploration with a review of what language is used to discuss adaptation and what is known about resonant frames. The section *Media Studies of Climate Change Adaptation Coverage* then takes a look at adaptation in media discourses, while the section *When Climate Change 'Comes Home': Cognitive, Psychological and Behavioral Responses to Impacts and Adaptation* examines a broad literature on perceptions and experiences of climate change impacts and how these experiences affect people's valuations and emotional responses to climate change. The section further examines interest in and acceptability and knowledge of adaptation, preferred timing and who should be responsible for enacting adaptive actions. The section concludes with insights from the literature on place attachment and identity, which – together with the other insights – goes a long way toward explaining the quality of debate on adaptation to date. All sections reveal important insights for improved communication but also identify important research gaps. These practical conclusions and research needs are synthesized in the concluding Section, *Synthesis: Implications for Practice and Future Research*.

What Shall We Call This Thing Called "Adaptation"?

To situate the challenge of communicating climate change adaptation, it helps to begin with an empirical survey of whether, and if so, how the term "adaptation" is used and, if not, what alternative phrases are being employed. From such a scan it becomes apparent how communicating adaptation sits at the intersection of communicating mitigation, communicating sustainability, and communicating risks and disasters[7]. This placement suggests that much can be learned from neighboring fields, but caution should rule the transfer of insights given that adaptation differs from those other issues in important ways.

The term "adaptation" in the climate change science community is commonly understood in the way the IPCC defines it, drawing on prior research by anthropologists, ecologists, and geographers: as any "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"[8]. While the technical literature offers various understandings[9], the climate science community has exerted a dominant influence on usage of the term in science and policy. One indication of this influence is in the UN Framework Convention on Climate Change (http://unfccc.int/), in which the term is used six times, anchoring it in international policy discourses as the complementary approach to mitigation (emissions reductions), both of which are required to minimizing climate change risks to society and the environment.

The term "adaptation" has been quite readily taken up in transnational, national and more localized discussions in Europe, Canada, Australia and Asia, as well as in development discourses (e.g., Refs. [10-12]), but it has not always been easily accepted in the United States. The resistance to "adaptation" frequently, but not uniformly, encountered in the U.S. is related to the challenge of communicating climate change more generally. Among those (often politically more liberal or Democratic-leaning)

municipalities and states, which are considered leaders on climate change action, efforts undertaken to prepare for and minimize expected climate change impacts are readily called "adaptation plans"[13]. In more conservative, Republican-leaning political contexts where climate change or sea-level rise are considered ideological positions rather than real phenomena[14, 15], early adaptation efforts are frequently not named as such but rather hidden in disaster preparedness or hazard mitigation plans, general land use plans, or redevelopment strategies[16].

But this is only half the story. The other half affects U.S.- and non-U.S. audiences alike. The challenge that transcends cultural and political contexts is one of making the abstract concept of "adaptation" meaningful in real, imaginable, practical and acceptable terms to both decision-makers and lay audiences. This has lead to the invention of phrases like becoming "climate-smart", "climate-resistant" "climate-resilient", or "climate (or weather)-ready"; engaging in "climate-proofing", or simple replacements of adaptation with more familiar terms such as "preparation" or "preparedness", "readiness", "adjustments", "planning", "coping", "triage" and – borrowing from hazard management – "climate risk management" or "mitigating the impacts of climate change." Which of these alternative terms is chosen or resonant hinges in important ways on the interpretive value – or baggage, as the case may be – that is attached to the replacing term[12]. Some have equated "adaptation strategies" with "resilience (or resiliency) strategies"[17] (Figure 1). Yet others have simply absorbed "the climate question" into their work toward sustainability and no longer distinguish or emphasize phrases like mitigation or adaptation. In many instances, the term adaptation is never or minimally used and the idea introduced instead via concrete actions people tend to be more familiar with: installing irrigation, building a sea wall, managing fuel to prevent wildfires, ensuring food security, or establishing heat-health warning systems. For example, New York City Mayor Bloomberg, in announcing the city's widely praised adaptation plan on 11 June 2013, gave a 45-minute speech and not once used the word "adaptation," but instead only spoke of the concrete efforts that are or will be undertaken to build a "stronger, more resilient city" in the face of climate change and extreme events (video available at: www.mikebloomberg.com). By contrast, there are instances where all climate actions (regardless of whether they address the causes or consequences) are referred to under the rubric of "adaptation" (as all of them imply adjusting to change), or as "climate change actions" and "responses," suggesting maybe a desire for simplified communication and often the political preference for those actions that synergistically serve to reduce emissions and increase preparedness for climate extremes and change (e.g., wetland restoration, reforestation, increasing urban forest cover)[18].

FIGURE 1 *| PlaNYC: building a more resilient, stronger New York. Excerpt of inside cover of New York City adaptation plan released in June 2013 (Source: Ref 17).*

The plethora of terms in use is indicative of a range of influences:

- ***Novelty*** – Adaptation is still a relatively new term in common parlance, allowing a variety of terms to be "field tested" before one becomes widely accepted and a common understanding of it stabilizes.
- ***Jargon*** – Adaptation is abstract and wonky, which allows it to easily be used in different contexts (and hence is more easily used at international and national levels), but does not allow for simple, intuitive interpretation in specific (localized) contexts.
- ***Lack of access to adaptation science*** – Local practitioners frequently do not follow the peer-reviewed literature[19] and may not have ready access to the underlying body of scientific understanding, nor access to "boundary" experts who can effectively translate that science into praxis-relevant language.
- ***Actor preference*** – How adaptation is framed and presented often depends on the (lead) actors involved. For example, those already working on reducing social vulnerability may employ a different language than those coming from the conservation and biodiversity or infrastructure arenas[20].
- ***Value connotations*** – Adaptation may carry value connotations that are unacceptable or simply not motivational to different audiences. Other terms, such as reducing vulnerability or increasing resilience (often used in ways that are equally disconnected from the respective scientific discourses) or preparedness may evoke in some cases more desirable in other cases equally contested values[21].
- ***Intention*** – The use of a particular adaptation language – like all language – is often intentional and audience-specific, i.e., it is aimed at achieving a certain effect with the audience such as to be alarming, provocative, appeasing, inclusive, or encouraging[22, 23].
- ***Context-dependence*** – Climate change and adaptation are "domesticated" (i.e., translated from a global problem into a context-specific national or local problem) differently depending on the regions, economic, social or cultural contexts in which they are being communicated[24].
- ***Legacies*** - Adaptation, as the late-comer to the (national) policy and public debate falls into a discursive context that is colored by the historical legacies of communicating climate change

science and mitigation[25]. In the U.S., this context can be deeply polarized. Depending on the local context, there may be value in either using it or avoiding it, and in alluding to climate change and human causation or remaining agnostic on causes[18, 26].

Few studies have explicitly tested how adaptation is perceived or understood, which of the alternative terms or phrases are most resonant and why, and which are more or less well understood. Most often, alternative terms are used based on little more than hunches or personal preferences in a trial-and-error mode, a practice generally not recommended by communication experts[27, 28]. Some early research[29] found "preparedness" to be widely resonant with U.S. audiences. Another study[30] found the "preparedness" frame to be 15% more compelling than "adaptation," and 100 climate and sustainability leaders, and social science and communication experts subjectively judged the word "adaptation" to be "negative and demobilizing"[31]. By contrast, a more recent study systematically reviewing communication frames used in the online presence of 670 organizations across the U.S. found that frames emphasizing and prioritizing climate change impacts, disruptions and extremes and the need to prepare for them to be the second most commonly used approach, followed by frames that introduced and explained the notion of adaptation for species, landscapes and the built environment[32]. An emerging discourse around extreme events and their economic impacts in the U.S. was found to be powerful in drawing in influential actors and helping to break the climate change and adaptation impasse in many locations[33]. Finally, in a focus group study, Moser[6, 14] found adaptation to not be mentioned voluntarily, suggesting that the term is still largely unfamiliar to local audiences, but once mentioned was quickly accepted and elaborated on – without prompting – with the full complexity with which social scientists think of adaptation (i.e., not just particular technical options, but also governance changes, public engagement and education, financing, and so on). While difficult to generalize, and thus begging for further research, the finding suggests that engaged issue publics are quite capable of learning new terms and interpreting them correctly. Importantly, however, most of the studies found for this review are from the grey literature, suggesting an important area for future peer-reviewed research to solidify arguments for or against using the term "adaptation" with U.S. audiences. There are, to my knowledge, no similar systematic studies of how "adaptation" is framed, understood, and whether it is a compelling term in other regions of the world.

Media Studies of Climate Change Adaptation Coverage

The news media – despite important changes in the industry in recent decades – continue to play a significant role in shaping public discourse on important issues[34]. Their role in framing discourses, setting public and policy agendas, serving as information source on scientific matters for lay audiences, interpreting emerging trends and future projections in meaningful ways, and as feed into the online social media world are widely recognized. A recent study showed how media can also be instrumental in mainstreaming climate change concerns into other policy arenas[35]. Thus, it is relevant to ask how adaptation has been covered and discussed in the news – both in traditional print media and their

online derivatives as well as in the social media world. There are a number of reasons, however, why it is particularly challenging to track media coverage on adaptation:

- ***Linguistic bias*** – As discussed above, there are myriad ways of talking about adaptation in public discourse, the most challenging of which is when the word adaptation is not even used, but only sector-specific plans or actions are described (in coastal areas, for example, discussions of beach nourishment, or building hard shoreline protection, retreating from the coast or dealing with relocation of roads, airports or water-related infrastructure).
- ***Outlet bias*** – To make news searches manageable, researchers often focus on leading national (elite and popular) newspapers and/or magazines, and only reflect the discourse at that level; adaptation actions undertaken in local settings are easily missed that way. This is aggravated by the widely observed trend that small local newspapers and the number of qualified journalists that could report on these activities are in decline.
- ***Geographic bias*** – There is a well-recognized bias in climate change media studies in favor of developed nations[36, 37], thus not only under-representing insights from other parts of the world, but also biasing what types of issues are covered. For example, given the generally greater financial resources in developed nations, which enable large-scale infrastructure projects, an impression may arise that this is the sort of adaptation that mostly gets done.

Keeping these limitations in mind, what is known to date about media coverage of adaptation? A couple of early studies – interestingly focused on developing countries – found that reporting on adaptation to climate change in Latin America had been slim[38]. Similarly, Harbinson et al.[39] found through surveys of print, radio and television journalists from Honduras, Jamaica, Sri Lanka and Zambia, that editors and journalists had little interest in covering adaptation due to low levels of knowledge on the issue, insufficient financial resources, and incongruent habits and priorities. Boykoff and Roberts[36] undertook one of the first quantitative international comparisons, finding several notable trends. First, the global comparison confirmed that most of that coverage on adaptation came from Western European and North American newspapers, and – at much lower numbers – from English-speaking newspapers in Australia, New Zealand, the Middle East, Asia, Eastern Europe, and South Africa. Second, they revealed that adaptation coverage even in major newspapers of the most actively covering countries (the U.S. and U.K.), adaptation was substantively discussed in less than 1% of newspaper reports on climate change or global warming between 1988 and the end of 2006. This is confirmed in a number of smaller-scale regional analyses[40-42]. Third, Boykoff and Roberts[36] noted a significant uptick in coverage in 2006 (release of the "Stern Report"). Moser[4], based on a comparable analysis focused on U.S. newspapers only, but covering the period 1980-2009, found a similar pattern, including the multi-fold increase in 2006/7 . Boykoff et al.[43] extended the analysis to mid-2012, focusing on global, U.S. and Indian news media in particular and found coverage in the U.S., India and globally to peak in 2007 (release of the IPCC Fourth Assessment Report), again at an even higher level in 2009 (Copenhagen Conference of the Parties), and since then continuing on at a lower level (albeit higher than during the previous two decades).

Generally speaking, contents analysis of the available adaptation news coverage is slim and varies in extent and depth considerably among the few existing studies. Boykoff et al.'s study[43] is one of the few, more recent exceptions, showing that adaptation coverage in national elite newspapers differs considerably from more localized coverage: while the former mostly depicts the international climate policy debates and how countries like India (should) position themselves within that policy context, more local adaptation news coverage focuses on concrete impacts and spcific needs for adaptive actions.

Direct coverage of adaptation aside, I am not aware of any studies that examine news coverage of adaptation-related activities without calling them such in any particular sector or geography. Thus, what is missing most in adaptation media studies to date is an in-depth examination of contents, framing and related debates. This constitutes an important research gap. It is notable, however, that a recent review of print, online news, and social media coverage on climate change in 14 countries across the world found considerable discussion of climate change impacts and extreme events (which may or may not be linked to climate change)[44]. Takahashi and Meisner[42] also found a predominance of the "effects frame" (i.e., a focus on impacts) in their study of Peruvian news coverage; Asplund[45] found such an emphasis in specialized farming magazines in Sweden; and the same was true in the online presence of U.S. NGOs and government agencies[32].

Importantly, this growing focus in climate change news coverage need not directly lead to or include discussion of adaptation responses, but – as the continued dominance of mitigation policies suggests – may be used to point back to the need for global action to reduce emissions or prevent further worsening of climate change. While Corfee-Morlot[46], reviewing studies of climate media coverage, noted extreme weather events increasing climate change media coverage and that these extremes are increasingly linked to climate change, this is not always the case. Gavin et al.[47], for example, examined British news coverage of flood events between 2001 and 2007 and found links to climate change only infrequently; where a possible connection was discussed, the message was mixed and inconsistent. Dow[48], in analyzing regional news coverage of drought in the U.S. Southeast between 1997 and 2007, found fascinating detail on the fine-grained dynamics of vulnerability and higher-order impacts of water shortage as well as drought responses, but no discussion of climate change. A survey of TV and print news coverage of wildfire in the Western U.S. in the spring of 2012 and again in 2013 found that stories made a link to climate change in only 3% and 6% of cases, respectively[49, 50], with an increase to 14% during the summer/wildfire season[51]. Finally, in an analysis of media coverage in the Western U.S. on the link between water and climate, Resource Media[52] concluded that the water/climate connection is made nearly invisible and innovative adaptation solutions are hardly discussed at all.

Why? What explains this disconnect and missed opportunity? In addition to all the reasons listed above of why it is challenging to talk about adaptation at this time, several others come into play here:

- ***Global vs. local stories*** – Extreme events (like fire and floods) or resource scarcity issues (like water and drought) are local (or at most regional) stories, while climate change – given the legacy of how it has been reported for years – is still largely a global story[52]. With the global

climate story come debates about whether it is real, human-caused, and if so, what to do about its causes (i.e. mitigation policy issues), thus privileging debates that belong to science or policy beats, and to some extent are simply not newsworthy anymore.

- ***Missed opportunity or hesitancy by scientists –*** Scientists, as common sources of information on environmental news stories, often fail or are hesitant to make the connection between the local event and global warming[53]. This is particularly the case between individual extreme events and anthropogenic climate change, with a recent shift toward emphasizing the consistency of patterns of more extreme events with global warming theory[47, 52].
- ***Climate change skepticism among TV meteorologists*** – As an important source of news about weather extremes, audiences tend to turn toward local TV. Research[54, 55] has found a range of barriers among (publicly widely trusted) TV meteorologists to talk about global warming on and off-air, including skepticism of the human causation of climate change, making many of them hesitant to make the link between an extreme and the global trends, remaining agnostic on its human causation, or simply avoiding the issue altogether. Where weather forecasters felt comfortable talking about climate change, even in conservative media markets, trust proved to be the key ingredient that made such information acceptable to viewers[56].
- ***Perceived normality of some extremes and attribution to "Mother Nature"*** – Contemporary climate change did not "invent" extreme events, and in many regions of the world they are part of "normal" life. Sometimes they are perceived as cyclical[57], or simply as the angry outbursts of "Mother Nature" (an attribution not limited to traditional societies). While these perceptions are beginning to shift[58] (see also discussion below), where they prevail, they may hinder discussion of taking any actions outside the traditional "getting back to normal."
- ***Complexity of adaptation*** – Human adaptive activities are complex, and much adaptation to date involves only very early, agency-internal and "soft" measures taken to build capacity and begin planning, which can be less visible and interesting to news agencies.
- ***Limited acceptable solutions*** – Finally, one study[52] suggested that for some intractable challenges like water in dry regions or inexorable sea-level rise, socially acceptable solutions are "far and few between." By avoiding the connection to climate change, it is easier to stay away from socially insensitive and politically hot debates over unpleasant transformative changes.

The spectre of undesirable changes point to two other notable trends in media reporting on climate change impacts that are relevant to the question of communicating adaptation. One is victimization, the other catastrophic imaginaries. Farbotko[59] analyzed media reporting on the impacts of sea-level rise on the small island nation of Tuvalu, showing how the Australian media constructed Tuvaluans as tragic victims of environmental displacement and reduced their identity to individuals lacking resilience and resourcefulness. Similarly, Doultona et al.[60], in their review of British news discourses on climate change and development, found the poor generally portrayed as victims. Reifying poor people in this way is not only disrespectful, and often outright inaccurate, but may also be demoralizing and paralyzing[61]. Moreover, such framing also sets up a misleading dichotomy to populations in the richer, more developed nations, maybe permitting them to fall into a false sense of safety[62]. Meanwhile, potentially

demoralizing framings of pending apocalypse and irreversible tipping points have been examined by various authors[23, 63-67]. While intended to convey urgency and mobilize people into action, these authors surmise that the noted trend in news reporting may have just the opposite effect on readers. Further research on adaptation and related news coverage thus must not just examine what is talked about and how adaptation is discussed and framed, but how such different framings impact different audiences in terms of mobilizing them for adaptation action.

When Climate Change "Comes Home": Cognitive, Psychological and Behavioral Responses to Impacts and Adaptation

Policy- and decision-makers and lay individuals learn about climate change impacts in one of two ways, and typically through a combination of both: through indirect, mediated forms of communication from others (the media, peers, neighbors, community members, staff, teachers etc.) or directly, through experiencing changes in the environment. How these are perceived, understood, and interpreted, and how people conceive of responding to expected or experienced changes is influenced, in turn, by a wide range of influences – cultural, social, personal, and informational, but inevitably primed through whatever cultural filters and historical legacies exist around the issues at hand[68-70]. It is for this reason that the earlier sections focused on discourse and media coverage first, before turning to what is known about individuals' responses to impacts and adaptation.

Experienced Impacts

A striking finding – at least at first glance – from a review of 75 studies from across the world (Supplementary Material 2) is the frequency with which people say they are already perceiving changes in the environment, or believe they have experienced the impacts of climate change. Their reports do not only come from the most northern latitudes or higher altitudes where climate science predicts the signs of climate change arrive soonest and be most severe; they not only refer to extreme events but also subtle changes; and they are not only from indigenous peoples or others whose work and daily practices keep them in close contact with the environment (farmers, ranchers, natural resource managers). Such reports instead come from across the globe. Available studies appear to be biased by where there is research capacity to document these public perceptions and experiences, not by where the observations are being made. From the coasts of Latvia to the drylands of Kenya, from the urban U.S. to rural Bangladesh, from the floodplains of the UK to the fishing harbors of Tasmania, significant percentages of individuals studied (in quantitative studies typically ranging from a quarter to two-thirds of n) believe that climate change is here now, and will grow to be a more significant challenge later. A few studies have checked people's perceptions and stated experiences against objectively tracked climatic trends and determined that many of these observations are in fact borne out in reality[71-74].

This finding of widespread experience of climate change is an astonishing finding in light of the oft-repeated statement that global climate change cannot be experienced directly, compounded by the

equally well documented finding, that many people still place climate change in the distant future. Both in small-group focus groups or interview studies as well as in national surveys, distancing is a persistently observed issue[75, 76]. How can these two findings be reconciled, leaving differences in methodology and geographic biases in the literature aside? Several explanations are possible:

- ***Range of perceptions*** – All studies find a range of personal perceptions and opinions, thus having some percentage of people state that they already have experienced climate change, and another portion state that they have not experienced them is simply a logical truism. It may also suggest that society is in a transition period from a prevalence of threat denial to increasing threat acceptance. Such differences are influenced by factors such as geographic location, outdoor experience and observation, personal experience of extreme events, knowledge about climate change, differences in values and beliefs, gender, social influences such a perceived peer beliefs, etc.[77-81].
- ***Context-sensitive simultaneous truths*** – It is also possible that people believe both to be true at the same time, but context matters as to which of the two truths comes out. Particularly the context in which individuals are asked the question makes a difference. For example, if researchers are interested in people's motivation to take personal action, especially undesirable (inconvenient, expensive or otherwise negatively perceived) adaptive actions, respondents may be motivated to place climate change in the far distance so that the action does not have to be taken immediately. In contrast, if researchers ask whether "someone" should take action to alleviate the climate change problem, acknowledging that it is here already adds urgency to the answer.
- ***Researcher-subject interactions*** – There is the ever-present possibility that researchers influence their subjects and that subjects want to appear a certain way to the researcher. A fine point on this generalized challenge is the possibility – especially in highly polarized and in emotionally charged contexts – that subjects have unacknowledged, maybe unconscious, emotional experiences that color their responses. For example, there is much anecdotal evidence, as well as focus group and deliberative process research that shows people have very strong feelings or hold strongly polarized beliefs about climate change. They may wish to either avoid them or use a situation perceived as safe (in a research context) to express these feelings. Thus research may especially bring to the fore these two extreme views – issue avoidance and distancing on the one hand and cathartic acknowledgment of the problem on the other.

Attribution of Observed Changes

Studies yield varied results as to the causes people identify for the observed changes in the climate and the environment. As Suppl. Mat. 2 illustrates, in many pre-literate, traditional communities and in regions distant from mainstream media influences, observed changes are either explained as acts of God, humans having angered the gods, natural variability, or as unexplained changes. In the rest of the world, attribution to anthropogenic climate change, natural variability, a combination of both, or other human influences on the environment (e.g., deforestation, changes in land use) are made, with and

without factual knowledge. Here the influence of media communications, interpersonal communication, and the importance of pre-existing beliefs, values and worldviews is particularly evident[30, 82-85]. Where attribution of observed changes to human-caused climate change meets deep ideological polarization, recent focus group research found it to be useful to remain agnostic as to the causes in an attempt to initiate communication about adaptation at all. Even those in denial about climate change or most skeptical of the human role in it could agree that it is necessary to deal with the apparent changes and to prepare for additional changes, as it fit their values of preparedness, responsibility, and being "better safe than sorry"[26].

Valuation and Emotional Responses to Climate Change Impacts

People's evaluation of how serious, worrisome or important climate change is – on a rather superficial level – has been well documented in many surveys (some included in Suppl. Mat. 2). For a relatively small percentage of people the issue is of utmost urgency, for the vast majority of people, however, when compared to other non-environmental issues, it ranks near the bottom of common lists of concerns, and even in comparison to other issues framed as "environmental", it is rarely as top-of-mind as clean water and healthy air. The disconnect lies in part in the perceived immediacy and weighed importance compared to current and more imaginable problems (for examples see Refs. 86-90).

As Suppl. Mat. 2 illustrates, climate changes are not uniformly perceived as negative, though in the majority of cases they are. To the extent impacts are psychologically distanced (i.e., placed as occurring far away, in the future, happening to other people or other species), individuals can either be relatively unconcerned and not (yet) feel personally at risk, or – quite to the contrary – can allow themselves to feel considerable concern because it is not affecting them, thus not evoking psychological defences). Personal concern and feeling at risk – as the well established literature on risk perception suggests – increases when a hazard can happen to me or my children, now or in the near future, when it unfolds suddenly (as opposed to gradually over time), is human-made (rather than natural), when it does not also involve personal benefits, when it is imaginable (i.e., personalized as opposed to abstract), and when it is imposed and there is little control over it[91-95]. Thus one might hypothesize that risk perceptions will increase as climate change impacts become ever more noticeable. However, psychological defences, including denial, may also be increasingly activated) Participatory research with groups of stakeholders using visualizations has proven helpful in overcoming some of these challenges by making the global and abstract more locally and personally relevant and tangible, thus increasing concern and willingness to take action sooner rather than later, while also offering the opportunity to discuss solutions together, thus countering feelings of helplessness[96-98].

An emerging literature on *emotional experiences* that people have in response to climate change impacts goes deeper however. Leaning on Kübler-Ross' model, the notion of “climate grief” has been popularized by climate scientist Steven Running[99], and mental health implications of weather disasters are increasingly recognized as important health effects[100-102]. Yet there is much ridicule of “eco-anxieties” in the blogosphere. A growing number of empirical studies and applications are emerging[103-

[105] that take seriously and try to understand emotional responses to climate change. Typically involving focus group, in-depth interviewing or various forms of participatory and deliberative research, these studies reveal a wide range of intense and specific emotional reactions, ranging from generalized distress[106, 107], to anxiety and a deep sense of vulnerability[108, 109], to wide-ranging worries, sadness, a sense of futility, hope- and helplessness, overwhelm, and anger[6, 14, 110, 111], to intense fears, cool dismissal, and denial[112, 113].

While "motivated reasoning" is a widely recognized phenomenon[70, 114] as a way of filtering out information that causes cognitive dissonance[115], much of the emphasis in climate change research has been on the management of dissonant ideas and beliefs[69, 71], less so on the management of negative affective experiences.

Compelling attempts to explain the range of deeper emotional responses, particularly intense feelings and corresponding "coping mechanisms" such as denial and apathy, focus on experiences of existential threats[116-123] and self-esteem and identity[124-128]. A clear, but challenging implication for the communication of climate impacts and adaptation flows from this work: if climate change (and adaptation) raise existential or identity related threats in people, then the communication challenge is not merely, and maybe not even primarily one of conveying science and information about adaptation options, but about respecting, holding, and dealing with perceived threats to the self.

Preferences, Timing and Perceived Responsibilities for Adaptation

Studies on lay publics' and government officials' understanding of and attitudes toward adaptation have received only some attention to date (Suppl. Mat. 2). Semantic and conceptual confusion notwithstanding, knowledge of adaptation is limited where managers and policy-makers are only beginning to think about it, where adaptation is believed to be something completely new and different from traditional management, or where there are truly new approaches proposed[86, 129, 130]. Knowledge among lay publics as to how to prepare for or protect themselves against impacts is often limited and strongly socially conditioned[14, 90, 131, 132], but past experience with climate variability and extremes is an important (but not all-knowing) teacher[72, 110]. Issue publics tend to be better informed and therefore more willing to engage in discussions of adaptation[14].

To the extent global risks are invoked, or local impacts are perceived as unknown, overwhelming or beyond individual control, studied populations generally tend to want governments to take on necessary adaptation actions[79, 133, 134]. But notions of responsibility for adaptation are generally quite complex. Leadership, guidance, and funding are the most commonly desired inputs from higher levels of government, whereas local government, business and industry, and individuals are seen as all needing to do their part, and frequently are deemed as being in the better position to decide on local matters[14, 90, 135-137]. Many also despise government mandates or regulations to determine how individuals respond to the growing climate change risks.

As for timing, to the extent individuals, companies or communities are not already reactively adjusting to the changes underway[72, 85], most studied populations favor – in principle – pro-active planning and preparation for the impacts of climate change, as opposed to "wait and see" or "cleaning up after disasters"[88, 138]. However, evidence with adaptation activities to date in the U.S. and elsewhere suggests that initial adaptation planning efforts at the local level do little more than focus on disaster preparedness and recovery (e.g., "getting back to normal" after Superstorm Sandy) without much attention to the changing climate.

Finally, in the studies available, respondents quickly see beyond the false choice between mitigation and adaptation. They recognize the necessity for both, and in fact frequently still favor mitigation as they understand the futility of adaptation if the problem is not addressed at its root causes[14, 139, 140]. Thus, the continued reluctance to address adaptation due to a perceived threat to mitigation may be outdated. Further research could resolve whether, where, and under what circumstances the two climate responses conflict in engaging the public.

Acceptability of Adaptation Options

It is impossible to derive broad-brush conclusions about the wide range of adaptation options, contexts in which they are applied, and the many social considerations that go into judging the acceptability of adaptation choices. But available studies do hold interesting insights relevant for the communication of adaptation.

First, as studies compiled in Suppl. Mat. 2 suggest, no adaptation action is automatically – by virtue of some inherent characteristic – acceptable or not. For example, coastal retreat, while often rejected is considered the most preferable option among some stakeholders. For some it is acceptable now, for others only considered an option of last resort. The same is true for migration and other major, transformative adaptations.

Second, acceptability of different adaptation options (drastic or not) depends on an intricate interaction of how people assess the risks they face and the nature of the response options they have in light of their capacities, understanding of self and others, and a variety of contextual factors (Table 1).

Table 1: Factors Motivating Acceptable Adaptation Actions (not prioritized)

Threat appraisal

- Clear and vivid risk awareness ("feeling at risk"; imagining the affective consequences; can be aided by geographic position, visualization, recent personal hazard experience, understanding of climate change etc.)
- Strength of belief in local effects of climate change
- Degree and understanding of uncertainty, attitudes toward uncertainty (tangibly communicated)
- Degree of non-adaptive behavior (e.g. denial, wishful thinking)

- Existence and belief in safety of existing protections
- Cultural cognition of risk (motivated reasoning)
- Trust in scientific information, forecasts, tools

Response appraisal

- Information about possible adaptation options/actions
- Perceived adaptive capacity
    - Self-efficacy (confidence in one's ability to enact the adaptation, incl. skills, health, sense of control over decisions, sense of being powerless and helpless, etc.)
    - Group efficacy (regarding collective adaptive action)
    - Response efficacy (confidence in the effectiveness of the adaptation to solve the problem, aided by feedback on effectiveness of past actions)
    - Costs of adaptation actions vs. access to resources
- Clearly perceived benefits of adaptation option, incl. non-monetary, intangible benefits
- Perceived fairness
- Social acceptability of adaptation options
- Social influences (social norms, peers exhibiting adaptive behavior etc.)
- Community support, social capital
- Trust in authorities

Self-Identity

- Orientation toward the common good
- Values, beliefs about personal responsibility, family role, professional role etc.
- Attitudes toward change

External support (influencing threat and response appraisal)

- Education
- Effective risk communication and engagement
- Financial and non-financial incentives
- Meaningful participation in governance/decision-making and deliberative processes
- Transparency and accountability in governance
- Establishments of beneficial defaults

Sources: [79, 89, 93, 131, 132, 141-156]

Across the many different situations, there appear to be a number of critical and distinct, yet interrelated mediating factors that foster acceptance or resistance, including:

- ***Familiarity*** – The familiarity with the adaptation options, i.e., the extent to which similar options have been used in the past, and thus not only have created structural, socioeconomic and cultural path dependencies, but are imaginable both in terms of costs and benefits;

- ***Necessity*** – The degree to which individuals recognize the necessity for the adaptation option under consideration and see a proportionality between the risk (including its associated uncertainties) and the adaptation option (including its costs, perceived benefits and potential side-effects);
- ***Resonance with perceived roles of different actors*** – The degree to which stakeholders see the enactment of a particular adaptation option to be consistent with their expectations of what the responsible party should be doing;
- ***Inclusive governance*** – The degree to which affected stakeholders are included in the deliberation and decision-making process of choosing among adaptation options;
- ***Compulsion*** – The degree to which an adaptation option is imposed on those who will have to enact it by government versus by nature;
- ***Choice and control*** – The degree to which stakeholders have control over when and how an adaptation is implemented, which includes control over resources, design, and timing.

Importantly, as existing studies and practical experience with adaptation efforts suggest, adaptation to climate change – even if it is not explicitly called that – occurs not on a blank slate, but in the context of current pressures and political and management legacies of the past. If there is a history of distrust between government and individuals, no adaptation effort will be able to escape that legacy[14, 157, 158]. Deep-seated expectations (often codified in law, social norms or other institutions) about private property rights, resource access, home rule, financial assistance, economic opportunity, or social justice shape the expectations about what rights and responsibilities, resource availability, habitual behavior, and relationships will continue on into the future[159-161]. Adaptation as a form of innovation may upset that apple cart. Thus – contrary to the assumption mentioned in the introduction that adaptation is easier to talk about than mitigation or climate science – adaptation cannot be expected to be any less conflict ridden than other charged debates over long-held expectations. Climate change disagreements will only heighten these other social conflicts. How they play out specifically, and what exactly the points of contention are, is highly context- and place-specific.

Place Attachment and Place Identity in Communicating Climate Change Adaptation

A crucially important extension of the focus on self-identity in the context of climate change impacts and adaptation is the growing understanding of place attachment and place-based identity[110, 162-168]. In this literature, places are understood as more than mere backdrop to or stage for human activity and experience (and thus to communication)[169, 170]. Places *become* locales of importance through the personal meanings instilled in them, through the emotional experiences had there, the learning and growth, family and other social ties, occupational and recreational practices, and spiritual practices enacted. These ties to nature, land or place (just as relevant in urban environments) create an expanded sense of self. Social and physical-ecological dimensions of place attachment can differ in relative importance but both play a role[171-173]. In this way, people take "ownership" of places (even if they do not legally own them); they develop a deep sense of belonging[174]. Differently put, places become *relationships*, and climate change impacts or adaptation actions that impact places thus affect this

person-place intimacy. Disruption of these relationships or displacements from places thus can cause grief and mourning[175, 176], resistance and defensiveness to change (e.g., retreat from the shoreline or floodplain)[163, 177].

As places become imbued with identity, i.e., as identity is at least in part constituted as a place-based phenomenon that is reproduced through personal interactions with place and social and cultural practices and narratives[178, 179], values become anchored in places[180]. In turn, values give meaning to events, motivate behavior, influence perceptions of (climate) change and adaptation options, and guide the interpretation of situations as they unfold[111, 181, 182]. In coastal Louisiana, for example, researchers noted how the slow process of coastal land loss due to relative sea-level rise forced a constant and heightened awareness of place attachment. The physical fragility of the place was reinforced through perceptions of political alienation from decision-making processes[177]. Much remains to be learned about how individuals and communities come to adjust not just externally, but internally, to "living with" climate change[183].

Not surprisingly then, pro-social, pro-environmental and appropriate risk-related behavior such as proactive adaptation are found to be enhanced when place identity is invoked and embedded in environmental communication[14, 80, 184]. Publics are more easily motivated and mobilized to act personally and civically[185-187]. Engaging place, place attachment and place identity thus can be promising paths forward in communicating climate change impacts and adaptation (Carbaugh[188] goes as far as to call it "communication *to* places"), and serve to better understand the deep drivers of debates over climate change responses. Examining the emotional landscape and its link to people's place attachment could help elucidate whether the harsh debates in contemporary climate change and adaptation disputes are at least in part fuelled by the unconscious and unaddressed emotional responses that climate change evokes in people as the increasingly visible impacts on the places people hold dear and are part of them[14, 189].

Synthesis: Implications for Practice and Future Research

This paper reviewed the emerging literature on communicating climate adaptation, drawing on diverse insights from research and practice. While focused research on adaptation communication is still limited, much relevant work exists. The introductory section established a growing need for guidance on communicating adaptation, for linking science and practice discourses across scale, and for a better understanding and easier navigation of the opportunities and challenges that arise with adaptation. It asked four specific questions that now can be answered:

What – if anything – is unique about communicating adaptation?

Research and practical experience suggest that communicating adaptation in many ways is not different from communicating climate change or other risks more generally. Basic tenets of effective practice,

such as knowing one's audience, relating to people in ways that resonate with preexisting values and beliefs, engaging respectfully and addressing the whole human being, not just assuming that there is an information deficit, tapping into deep motivations and understanding resistances and barriers to action – all of these hold as firmly as ever in communicating adaptation.

However, adaptation to climate change also involves unique communication challenges that must be taken seriously. Single, unpredictable hazards like volcanic eruptions or earthquakes are different from progressive and continual change; a simple fix like an invisible modification of a smokestack that makes a problem "go away" is not at hand for climate change, which will persist and involve long lag times and uncertainties. Despite repeated and costly interventions, things may still get worse and the unattractive choice may be between some loss and unacceptable loss.

In addition to characteristics of the hazard, public engagement on adaptation is also deeply dependent on the context in which it takes place: it takes place in contexts that may be polarized from previous communications and conflicts over climate change; in others there is no pre-existing knowledge of climate change at all. In either place there will have been land use, resource management, disaster management and public health discourses and management experiences that will color how adaptation is perceived. At all times there are deeply held social expectations and histories that must be understood so as not to step on social or political "landmines" that can undermine the success of engagement efforts.

The place-specific nature of local communication of adaptation also holds challenges and opportunities. Because people are deeply related to, and self-identify via the places they inhabit and use, tapping into place attachment can prompt pro-social, pro-environmental, and appropriate proactive behavior. On the other hand, when place identity is threatened – symbolically or actually – self-protective defenses can make engagement on adaptation more difficult. At the deepest level, adaptation is a response to destabilization (and in some instances to existential threat) and itself a form of destabilization (by creating more flexible structures and processes). As such it forces involved decision-makers and stakeholders to question everything they knew to be "true" and "just so," and creates a communication environment that is filled with uncertainty and anxiety. Communicators must be prepared for these challenges.

What do we know about how to communicate adaptation successfully?

Existing research and experiences from practice suggest a number of ways in which adaptation can be communicated effectively, though further research should test and confirm these suggestions:

Linking science with experience in communicating risks

- Depending on context (and the available science to draw on), attribute observed changes to anthropogenic climate change or stay agnostic on causes.

- Assist people in appraising the risks they face from climate change and the options they have in responding to them. Just as in other risk communication, never leave an audience without hope and actions that can be taken to alleviate the threat.
- Explain and visualize uncertainties in understandable ways and with clear relevance to the implications for actions at different times. Uncertainty works both ways: threats may materialize sooner or later, and may be more or less serious when they do. Help people consider scenarios.

Adaptation language

- If adaptation is an unfamiliar term, describe concrete actions first to illustrate what is meant by the term.
- Where adaptation is a negatively loaded term, reframe adaptation in ways that make it consistent with or extensions of responsible planning, existing high-priority management concerns, and already familiar decision-making in the face of uncertainty.
- Use language that taps into values that are resonant with the audience (preparedness, stewardship, responsibility, precaution, fairness, honesty, transparency, etc.).

Communicating adaptation choices

- Visualize the adaptation options, not just the risks from climate change, especially where the proposed options are new.
- Point to past experience (or experience in other locations) with similar adaptation approaches (such as relocation of communities out of floodplains, significant shifts in policy or regulatory environments, or creative financing and compensatory mechanisms) to establish familiarity with the new idea of adaptation, help the imagination, and create a sense of continuity in the midst of change.
- Illustrate how long a given behavior or management approach will work in light of climate change (and other stressors), and when a threshold may be crossed past which a particular social objective can no longer be achieved with "business as usual." Then show how well adaptation alternatives may achieve the objective.
- Communicate the costs and benefits (not just in monetary, but also in less tangible terms) of various adaptation options.
- Offer – where possible – a choice of ways to reach a particular intended outcome.
- Highlight how enactment of a particular adaptation option is commensurate with commonly accepted responsibilities of the involved actors (e.g., governments for larger infrastructure projects, individuals for home-related efforts).
- Use deliberative processes to arrive at a commonly agreed upon understanding of risks, desirable adaptation goals, and a range of adaptation options to achieve them.

Importantly, public engagement on adaptation and climate change often emphasizes small-scale interactions such as workshops, and this has shown to be effective for increasing knowledge, fostering deeper conversations, and transcending political differences[26]. But some community members may not like to interact in this way[157, 190]. Identifying appropriate participants, representatives, and modes of participation remains a key challenge[191]. If not paid attention to, engagement processes may suffer from

the self-selection bias of issue publics. Care must be taken in extending invitations to all affected parties[159].

Is it useful to communicate differently about mitigation and adaptation? And how can we translate between high-level and local discourses?

Existing research and practice gives no simple answer to these questions. Much depends on the pre-existing knowledge and communication on climate change. Where there is no or very limited prior knowledge of climate change, there is no reason why the two terms cannot be introduced, explained, and used in ways that are consistent with the climate science and international policy discourses. There is also no need to use such jargon at all and instead talk about concrete actions to address existing or expected problems. The more difficult situation arises when either the terms are negatively loaded, used in confusing or misleading ways or with different meanings. In such situations it is probably best to speak of concrete activities that help limit the causes and reduce the consequences of climate change, rather than perpetuate existing confusion or introduce communication "red flags." Those communicating about impacts and adaptation must simply become aware of and understand the different uses of terms – in their local context and the broader discourse – and serve as "boundary" individuals who can translate between them.

What are fruitful areas of further research and how can the results be rapidly transitioned into communication practice?

Finally, a number of important research gaps have been identified throughout this paper. Deeper understanding will not only strengthen and coalesce the science of adaptation communication, but can assist communicators in important ways.

- ***Meaning and acceptability of "adaptation"*** – Further research on whether or not adaptation is understood and resonant with different audiences, and how this perception and understanding changes over time, would help particularly in those locations, where climate change communication legacies may inhibit progress. Studies from outside the U.S. would allow for comparative insights.
- ***More comprehensive media analysis*** – Deeper examination of media coverage of adaptation, particularly in specific places or sectors, and especially where the term "adaptation" is not used, would much advance our understanding of how the issue is framed, made locally relevant and resonant, how this affects audiences, and what contents specifically is and is not talked about.
- ***Psychological effects of emerging climate change impacts*** – Research is needed to explain the seeming contradiction between psychological distancing and increasingly widespread experiences of climate change impacts in the here and now.
- ***Attribution of observed changes*** – How people come to understand and attribute causes to observed changes and to what extent this attribution is important for effective engagement on adaptation is rife for further study. Particularly in politically more conservative contexts, such

research has very practical relevance: how does one effectively move the conversation from the currently common focus on specific observed changes (without attribution to climate change) and more near-term responses to one that is forward-looking, longer-term, and explicitly considering persistent, directional and more volatile climate changes?

- ***Climate change as existential and identity threat*** – Furthermore needed is an improved understanding of climate change as an existential risk and threat to identity and self, what psychological coping mechanisms people employ, and – from a practical standpoint – what forums and forms of engagement may be needed, accepted, or appropriate in different cultural contexts to safely address these emotional experiences.
- ***Mitigation-adaptation relationship in public understanding*** – Future research must resolve whether, where, and under what circumstances mitigation and adaptation do indeed conflict in public engagement.
- ***Acceptability of adaptation*** – Much remains also to be learned about the factors that determine the acceptability of adaptation, particularly with an eye toward the implications for communication.
- ***Role of place attachment and place identity*** – And finally, given the place-specific nature of local impacts and adaptation, it would be helpful to better understand the role of place attachment, and place identity in public engagement – both how it can be used to constructive effect, and how it fuels debate and conflict over adaptation options.

While the list of research questions is long and likely not limited to these, the good news is there now is a well established field of climate change communications that can address these questions. As this review illustrated, many related fields of social science research offer essential and complementary insights. Thus, the outlook is promising that answers can be generated in relatively short order. Meanwhile, many boundary organizations, outreach and communication trainers, and web-based resource hubs have emerged in recent years that serve valuable services in making this research accessible and understandable to communicators across the world. Thus, communicating climate change adaptation will maybe never be easy, but it can be and is being made easier.

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Further Reading/Resources

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Related Articles

DOI	Article title
10.1002/wcc.011	Moser, SC. Communicating climate change: History, challenges, process and future directions. *Wiley Interdisciplinary Reviews: Climate Change* 2010, 1: 31-52
10.1002/wcc.120	Wolf J, Moser SC. Individual understandings, perceptions, and engagement with climate change: Insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change* 2011, 2:547-569.
10.1002/wcc.164	Fresque-Baxter JA, Armitage D. Place identity and climate change adaptation: A synthesis and framework for understanding. *Wiley Interdisciplinary Reviews: Climate Change* 2012, 3:251-266

Supplementary Materials

Supplementary Material 1: Methods and Justification of Approach to this Focus Article

Web of Science Search

This review is based on a synthesis of the available literature on communicating climate change impacts and adaptation. While this synthesis cannot claim completeness or comprehensiveness, it does attempt to touch on key aspects of communicating adaptation. A number of pathways were combined to identify the relevant literature. First, a Web of Science (WoS) topical search (1990-2014)[1] was conducted using the truncated search terms "adapt*" , "climat*", "chang*", "impact", and "communicat*". The 135 initial results were screened more closely based on title and abstract. In the end 31 articles (~23% of the initial 135) touched on some aspect of communicating adaptation. More than 80% of these have been published since 2009, a reflection of the well-documented increase in literature on adaptation in general[1], and of the growing interest in researching the communication challenges around it in particular.

However, such a search is fundamentally inadequate because it presumes that there already is a clearly identifiable research literature focused on the communication of adaptation. This would clearly be overstating the case. It further presumes that researchers use these five keywords to address adaptation communication concerns, but a vast array of relevant other research that touches on sub-aspects of this topic would be missed – e.g., studies of media coverage, of perception or understanding issues related to adaptation, emotional responses, discourse analyses, or the role of values and worldviews.

Supplementation through Additional Relevant Peer-Reviewed Literature

Thus, a subjective and selective choice of complementary research articles and book chapters was added to those identified through WoS to compensate for these short comings. A comprehensive search for all relevant communication concepts, however, is not practical. Some research results are thus likely to be missed through this search, even if many relevant topics are included to sketch the contours of this emergent field.

Supplementation from Other Sources

Finally, in addition to peer-reviewed literature, articles from other sources – such as media reviews, project reports, survey studies, adaptation planning documents – conducted by communication researchers and adaptation practitioners but only published in non-peer-reviewed sources were reviewed and included depending on quality and relevance. Given the rapid pace with which adaptation is emerging in practice, and communicating it is a priority for those engaged, there are many potentially useful insights gleaned from these sources, some of which confirm findings from the scientific literature,

[1] The following Web of Science search was conducted: Topic=(adapt*) AND Topic=(climat*) AND Topic=(chang*) AND Topic=(communicat*) AND Topic=(impact*); Time span=1900-2014. Databases=SCI-EXPANDED, SSCI, A&HCI.

others require further systematic examination or raise interesting research questions. Importantly, the addition of the latter two sources of insights (a broader scientific literature and practice insights) does not presume that adaptation is talked about as adaptation, as much empirical evidence suggests this is not the case. But it does assume that much relevant work conducted for other primary purposes reveals important insights for communicating adaptation.

As is the case with climate communication research more generally, and in fact with social science on global environmental change[2], there is a bias in regional coverage of communication research. North America, Europe and Australia dominate in peer-reviewed contributions on the topic, which is somewhat compensated for by the inclusion of reports stemming from practice. Yet it remains extremely difficult to capture the literature comprehensively and from all corners of the world. While examples will be cited throughout, no specific case exploration is undertaken in this review. Finally, initial judgment of "how successful" these examples is offered only cautiously as this review comes early in the emergence of the field, and as such is not yet capable of rounding up "best practices" – something that may remain elusive given the context-sensitivity of both climate change impacts, adaptation responses, and the social groups involved in the communications process.

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Supplementary Material 2

QUESTION	LOCATION	RESPONSES	REFERENCE
CHANGE: Is change (in weather patterns, climate or the environment) perceived?	United States Canada Malta	About 1/3 of Americans, ½ of Canadians and 2/3 of Maltese already perceive harms to health and well-being from climate change; when prompted, majorities believed to be vulnerable to respiratory and heat-related illnesses, injuries from extreme weather events and allergies.	[1]
	United States	Americans increasingly cite their experience of weather, particularly changing weather patterns, drought, heat waves and storms, as the primary factor in their beliefs in climate change.	[2]
	United States	70% of Americans believe that changes in weather extremes and seasonal weather patterns are occurring.	[3]
	United States	Survey respondents located on higher ground and further away from the coastline perceive lower levels of risk from climate change; those at risk of inundation from sea-level rise perceive greater personal risk. Living in a 100-year flood zone correlated with lower risk perception. Influence of weather variability on climate change risk perception was lower than expected. Where recent experiences of extreme events led to human fatalities, risk perception is increased. Overall, however, physical vulnerability factors have only weak explanatory power compared to socioeconomic and attitudinal factors, particularly personal efficacy.	[4]
	US (Michigan)	27% of surveyed adults has experienced climate change effects, especially changes in seasons (36%), weather (25%), lake levels (24%), animals and plants (20%), and snowfall (19%) (all changes borne out in the climatic record)	[5]
	US (various states)	In a series of surveys of outdoor hunters and anglers, respondents reported having notices significant changes in the climate and environment.	[6, 7]
	US (Gulf Coast states)	58 % of surveyed coastal residents said their local climate was very or somewhat different than in the past (particularly, more droughts, higher temperatures, more coastal erosion).	[8]
	US (Delaware)	Survey respondents living at the coast, compared to non-coastal residents, were more likely to "strongly agree" that they have personally experienced the impacts of sea-level rise. Men are more likely than women to think that sea level rise will start to have impacts in the distant future. Respondents could clearly name which assets would be at risk from SLR.	[9]
	US (Arizona)	Public perceptions of temperature during heat extremes are more strongly correlated with proximate environmental conditions than with distal conditions; and perceptions of temperature are related to social characteristics and situational variables (e.g., women, minorities, politically moderate or liberal, those who experienced a heat-related illness in the household, were older and long-time residents, or who had spent more time away from the study location were more likely to say it is a lot hotter than was observed during the	[10]

QUESTION	LOCATION	RESPONSES	REFERENCE
		heat wave). The study adds to the social constructionist literature of risk perceptions.	
	US (rural areas)	A survey of residents across nearly 20 rural counties of the US found a strong correlation between perceived climatic changes, particularly winter warming and snow cover changes, and empirically observed climate changes. Between 16 and 32% of respondents perceived major changes, another 28-38% perceived minor changes.	[11]
	Europe (longitudinal gradient)	Nearly 30% of surveyed private forest owners across Europe said they had definitely or probably experienced extreme events that they attributed to climate change.	[12]
	UK (England, Wales)	Only residents in close proximity of the sea and to the river estuary served to present a tangible and visible hazard felt themselves to be at risk from climate change and sea-level rise. Those further away perceived themselves at low or very low risk. Recent flood defense improvements contributed to the perception of low risk. Risk perceptions were low for floods where past experiences had faded, and for sea-level rise because interviewees could not envision a hazard that not materialized yet.	[13]
	UK (Wales	The Welsh public expressed high levels of concern about climate change (after years of relatively low levels across the UK), and the impacts are perceived to be close to home and relevant here and now. More than half of the respondents consider that their local area is likely to be affected, and/or already experiencing the effects of climate change. Those who have experienced flooding in recent years are more likely to perceive greater vulnerability of the region and are more likely to say the effects of climate change are already apparent.	[14]
	Australia and UK	Australian respondents viewed climate change as a more immediate, proximal, and certain threat to their local region and nation, than was the case for British respondents, for whom the problem was perceived to be more distant, uncertain, and less familiar in terms of anticipated consequences. 54% of Australian respondents and 41% of British respondents believed that they were already experiencing the effects of climate change. Australian respondents provided many examples of direct encounters with what they viewed as evidence of climate change in open-ended survey items.	[15, 16]
	Australia	A survey of coastal residents found polarized views regarding the risk of sea-level rise. A large number of respondents rejected the idea that rising sea levels are a serious threat and did not want an open public discussion about science or policy related to it. Those unsure or concerned about SLR see a legitimate role for government in addressing it.	[17]
	Mexico	A survey and in-depth interviews with farmers revealed that farmers perceive climate-related changes due to changes in rainfall, temperature extremes, seasonal changes and extreme events.	[18]
	Mongolia	Nomadic herders observe longer and more intense droughts and sand storms, as well as	[19]

QUESTION	LOCATION	RESPONSES	REFERENCE
		rainfall becoming more patchy.	
	Kenya (Laikipia District)	Farmers participating in interviews and focus group sessions revealed keen perception of drought and related climatic changes (less predictable rainfall, higher temperatures, changed wind patterns, more extremes such as hail, ice) over the past several decades. These changes are seen as overwhelmingly negative.	20
ATTRIBUTION: Are the changes attributed to a particular cause (natural variation, human-caused climate change, other causes, combinations of these)? Or is the cause not known?	UK (south)	Survey respondents and focus group participants attributed the 2004-06 drought to natural variability in climate and a range of human factors (water-intensive lifestyles, a growth in population, increasing housing developments, leaking pipes and the privatization of water companies).	21
	Central Nepal	Local farmers are highly aware of changes in temperature and rainfall patterns, but have not heard of climate change and thus do not know how to explain the observed changes.	22
	United States	In 2012,12% of Americans thought observed changes in weather and seasons are entirely due to humans changing the climate; 55% thought they are partly natural, partly human-caused. Of those who say, climatic changes are caused by humans, 92% (and 79% of those who say changes are cause by both human and natural fluctuations) are willing to take preparatory and protective action compared to only 54% of those who say change are just natural fluctuations.	3
	US (California, Yolo Co.)	While most surveyed farmers agreed that climate change was occurring and posed risks to agriculture globally, there was greater uncertainty as to whether humans were a contributing factor and if the local impacts would be positive or negative. Those who agreed climate change is causing risks were more concerned about regulation and higher energy prices than about water scarcity and pests; they were also more likely to adopt mitigation and adaptation practices related to water management.	23
	US (various states)	In a series of surveys of hunters and anglers, upwards of 60% of respondents in four out of six states, attributed observed changes in the climate and environment to "global warming."	6, 7
	Asian (Mekong region)	Many local residents make observations of change in their physical and ecological environment, but knowledge of climate change is limited. Rarely are the observed changes attributed to global warming.	24, 25
	Australia (Tasmania)	Most of the interviewed farmers believed that climate change was underway and that they had personally experienced changes that they attributed to climate change. Yet many did not believe the causes were anthropogenic or were undecided about them.	26
	Australia (NE Arnhem Land)	Interviewees reported observing changes in their ecological landscape, which they attributed to mining, tourism development, and climate change. 'Strange changes' noticed particularly in the last five years, had caused concern and anxiety among many participants. Despite their concern about ecological changes, participants were primarily worried about	27

QUESTION	LOCATION	RESPONSES	REFERENCE
		other issues affecting their community's general welfare.	
	Canada (Quebec, Gulf of St. Lawrence)	Many (but not all) residents in coastal communities observe a variety of environmental changes (loss of coastal ice cover, change in precipitation, increased erosion and loss of beach width, rise in high water, storm changes, milder winters, etc.). Most respondents see climate warming as a cause behind proximate changes in climate and the environment.	[28]
	Russia	Local narratives about climate change largely reflect climate skepticism, and anthropogenic climate change is rejected as explaining environmental changes because: (1) climate is considered as naturally and cyclically changing, (2) humans are not considered a large enough force to alter natural climate cycles, (3) environmental problems are solvable with technology and (4) there is a lack of knowledge about climate change science. Thus, perceptions and emotions about transformation focus on other realms—socioeconomic, political, cultural—that are perceived as more critical to everyday life in the present and near future.	[73]
	Fiji, Rewa River Delta	Current impacts of climate change, such as floods, riverbank erosion, groundwater salinization, are perceived as some of the most serious environmental challenges at present, but few understand the causes.	[29]
	Tanzania (northeast Zanzibar, Unguja Island)	Coastal communities engaged in a wide variety of subsistence and tourism-related activities observed stronger or weaker waves (depending on location), vegetation loss, erosion, stronger winds, and – perceived as most serious – floods and waves encroaching higher onto the shore. Explanations involved natural changes, divine intervention (acts of God) or punishment, and human activities	[30]
	Mexico (Chiapas)	Indigenous populations observe changes in rainfall patterns and temperature but don't attribute them to climate change (a culturally unfamiliar concept), but to regional vegetation changes and the eruption of El Chichón in 1982.	[31]
VALUATION: Are the changes seen as positive, negative or neutral?	Port authorities, globally	Sea-level rise considered of great concern, but not an immediate threat; storm-related issues (flooding, wave impact etc.) also of considerable concern; half of respondents thought climate change would bring opportunities	[32]
	US (Florida)	A large majority of surveyed experts and decision-makers viewed climate change as already underway and were highly concerned about adverse local impacts (74%), particularly the threat of significant sea-level rise (72%), massive loss of coral reefs (74%), degraded ecosystems/habitat loss (73%), species loss and/or extinction (72%), beach loss (72%), private property loss (70%), more frequent flooding (68%), more destructive hurricanes (65%), permanent loss of public lands (63%), loss of tourism revenues (62%), and higher insurance premiums (90%).Female respondents showed statistically significant greater concern and readiness to act.	[33]

QUESTION	LOCATION	RESPONSES	REFERENCE
	US (California)	Sea-level rise was judged to be "bad" and a "serious problem" by 71 and 79% of respondents, respectively.	[34, 35]
	Canada	Because coal mines are sensitive to climate hazards, there is concern about climate change among coal miners, but the majority of survey participants have not yet noticed climate change to be affecting operations. Future climate change is expected to have negative impacts for mine operations, but actual knowledge of potential climate change impacts is limited.	[36]
	German Baltic Coast	Regional decision-makers judge the majority of climate changes (except warmer summers and winters) to have negative impacts on the region; there is ambivalence in valuation over changes in precipitation.	[37]
	Australia (Tasmania)	Most interviewed farmers saw opportunities for Tasmania in a changed climate. They expected Tasmania to be sheltered from the worst effects of climate change and, therefore to be relatively benefited.	[26]
	Australia (South)	Surveys and participatory GIS with stakeholders revealed that climate change risk perceptions are driven, in part, by the values people assign or hold for places on the landscape. For example, biodiversity, aesthetic and intrinsic landscape values have strong spatial association with biodiversity loss risk while recreation and aesthetic values have strong spatial association with riparian flooding, sea-level rise and wave action risks. The results help prioritize adaptation areas, based on people's perceived landscape values.	[38]
	Australia (national)	Survey respondents who had visited the Great Barrier Reef in the preceding twelve months were more likely to report being very concerned about climate change than were respondents who had not visited the Great Barrier Reef over that time.	[39, 40]
	Australia (national)	Survey respondents completed a seven-item measure of experienced psychological distress with respect to the threat of climate change. 20% of respondents reported feeling, at times, appreciable distress at the prospect and implications of climate change and its consequences.	[15, 16]
EMOTIONAL RESPONSES TO IMPACTS: What emotional responses do people express?	German Baltic Coast	While regional decision-makers judged sea-level rise as "less important" than climate change, they expressed considerable concern over climate change and sea-level rise.	[37]
	US (Gulf Coast states)	61% of surveyed coastal residents expressed at least some concern, but were not overly alarmed, about changes to the local climate. The greatest concerns about future climate changes revolve around hurricanes, flooding droughts and water supplies.	[8]
	US (Delaware)	Three years before Hurricane Sandy, survey respondents ranked climate change and sea-level rise as #9 and 10 out of 10 big national issues to be "very concerned" about. Similar low ratings were found when focusing only on "environmental issues for Delaware." Women were more concerned than men. When asked specifically about climate change and	[9]

QUESTION	LOCATION	RESPONSES	REFERENCE
		sea-level rise, 53% and 39%, respectively, said they worried about it "quite a bit."	
	US (California)	Focus group participants (homeowners of shorefront property) expressed a variety of emotions around observed and anticipated climate and related shoreline change in the context of an environment which they loved (described as magical, paradise, treasure, wonderful, idyllic, restorative, and special). They expressed worries and concerns about the coastal environment that, quickly and without prompting, involved climate change; they also expressed a sense of futility, hopelessness, helplessness, overwhelm, sadness, and anger.	[41, 42]
	Tanzania (northeast Zanzibar, Unguja Island)	The overall perception of change in the coastal environment was negative and communities felt very vulnerable due to the array of harmful activities (such as sand mining, tree cutting and vegetation clearance). The communities did not perceive themselves as passive victims, however, but suggested a variety of measures to reduce the impacts of coastal change. The array of the proposed measures all reflect the adaptive capacity of the communities, i.e. measures believed to be possible and more or less effective.	[30]
	Canada(British Columbia)	Concern among participants of a visualization and visioning session was generally greater about impacts globally and on future generations than on their local community and themselves. This concern grew after the visualization session.	[43, 44]
	Norway	People were found to avoid thinking about climate change in part because doing so raised fears of ontological security, emotions of helplessness and guilt, and was a threat to individual and collective senses of identity.	[45, 46]
	Sweden	In-depth interviews with Swedish reindeer herding Sami revealed that herders already experience severe and more rapidly shifting, unstable weather with associated changes in vegetation and alterations in the freeze-thaw cycle. They perceive them as one more stressor among their daily struggles. Other societal developments have limited their adaptive options or altered their traditional lifestyles. Forecasts of additional changes from scientists and authorities have added to stress and anxiety.	[47]
	The Netherlands	The experimental studies suggest that both fear about climate change and information can increase intentions to act, but group efficacy is more important than personal efficacy in mobilizing collective response to a problem (like climate change) that is perceived as a global problem beyond an individual's ability to solve.	[48]
	The Netherlands	Surveys of recent flood victims and non-victims revealed that victims reported stronger emotions (negative and positive), and the receipt of more social support due to past flooding than did non-victims. Moreover, victims worry more about future flooding, perceive themselves as more vulnerable to future flooding, perceive the consequences of future flooding as more severe, and have stronger intentions to take adaptive actions in the	[49]

QUESTION	LOCATION	RESPONSES	REFERENCE
		future than non-victims. The link between past experience and action involves a threat appraisal and a coping appraisal.	
	Canada (Labrador)	Data gathered through a multi-year, community-driven project in Rigolet, Nunatsiavut, Labrador, Canada, make evident that the emotional consequences of climate change are extremely important to Northern residents. Observed environmental changes include changes in ice conditions and freeze-up times, levels of snow and rainfall, and changes in seasonal temperature. Experiences include disruptions of the sense of connection to the land (emotional ties, respect, love and commitment to the land) and of the ability to connect to "something bigger" (spiritual connection), uncertainty, anxiety and frustration related to the unpredictability of the environment; sadness, helplessness, anger, disappointment, worry and a host of other emotional responses. These noted changes in the land and climate this directly impact emotional health and well-being of the Inuit population.	[50]; see also [51]
ADAPTATION KNOWLEDGE: What do people know about how to minimize risk or take advantage of opportunities?	Port authorities, globally	Infrequent discussions of adaptation among most ports; very few have planning horizons longer than 10-15 years; most only consider historical extreme event data in design standards	[32]
	UK and Switzerland	People understand the difference between mitigation and adaptation and are willing to support both, but would like to see more mitigation action	[52]
	US (California)	Residential water users have little knowledge of their water use (quantity), and believe they use far less than the state average; but they wish to act responsibly	[53]
	US (Delaware)	A survey of state residents found significant information needs on the relationship between climate change and sea-level rise, local climate change and SLR impacts, and how people could protect themselves against them.	[9]
	US (California)	Focus group members (homeowners of shorefront property) varied in their knowledge of adaptation options. Those more familiar with coastal management issues more generally fully understood the range of adaptation options. They clearly recognized the limitations of piecemeal, property-by-property protection efforts (e.g. seawalls or riprap) and pointed toward larger approaches (e.g. regional sediment management) and far more fundamental interventions (e.g. changes in electoral politics and greater community engagement in local politics, basic education of children and the public, change in worldviews).Those less familiar felt hard pressed to venture into the topic since it seemed to demand more technical knowledge than they felt they had.	[41, 42]
	Europe (mostly Southern and Eastern Europe)	Interviewed experts reported observed increased frequency and severity of extreme weather events and were very concerned about future impacts such as expected increasing damage costs and mortality rates. Floods, droughts, and heat waves were most easily	[54]

QUESTION	LOCATION	RESPONSES	REFERENCE
		observed, sea-level rise less so. Blame was put more often on human land use and management, including past maladaptive measures than on global warming. Extensive knowledge of different adaptation options exists but opinions on effectiveness differed widely and preferences for mandatory vs. voluntary, top-down vs. bottom-up strategies were predictable given prior held beliefs and positions.	
	UK (East Anglia and NW England)	Ability and acceptability of adaptive responses to climate change risks is framed as, and depends on, people's understanding of who is responsible, and what policy- and decision-making procedures exist to address risks.	[55]
	UK (south)	Survey respondents and focus group participants expressed concern about the potential for more droughts under climate change, but their concern did not translate into action due to lack of accessible information, a lack of knowledge regarding the integration of environmental spheres, a lack of resources, and a perceived lack of institutional engagement.	[21]
	Kenya (Laikipia District)	Farmers participating in interviews and focus group sessions revealed extensive knowledge of coping and adaptation strategies in response to perceived/experienced changes. They preferred to combine multiple options (crop diversification, use of veterinary services, relief food, migration/employment elsewhere, sale of livestock, borrowing etc.) and the selection of options was directly linked to perceived climate risks.	[20]
RESPONSIBILITY: Who is perceived to be responsible for taking possible actions?	UK and Switzerland	When global risks are perceived, policy action by governments is preferred; when local risks are perceived, individual action is preferred. ü	[52]
	UK (England, Wales)	For interviewed floodplain residents, responsibility to act on sea-level rise, as yet a largely 'unknown' hazard in the local context, responsibility is transferred to others (government).	[13]
	US and California	Higher proportions in California than nationally believed that state government (59%/53%), local coastal governments (55%/52%), the federal government (52%/45%) and coastal businesses (55%/45%) should do "a great deal" or "quite a bit" to address sea-level rise impacts. In California 50% wished for the government to carry the financial burden for adaptation while 48% said the affected people and businesses should pay. Nationally 60% preferred affected individuals and businesses to pay and only 38% wanted government to foot the bill. If tax increases were to pay for adaptation measures, four out of five believed only coastal property taxes should increase, not everyone's. Coastal property owners, and slightly less so coastal renters and visitors from inland areas should pay.	[34, 35]
	US (Northern Inland West)	Focus group participants believed that the government has responsibility for managing publicly owned forests, but does not "owe" safety to the people who choose to live in the wildland-urban interface; most felt that homeowners must take greater responsibility for having defensible space around their homes to protect those responsible for wildland and	[56]

QUESTION	LOCATION	RESPONSES	REFERENCE
		wildfire management.	
	US (Delaware)	Survey respondents felt – by two-thirds majority – that everyone should do more to prepare for and manage the impacts of sea-level rise, but at the top of the list of entities that should do more were corporations and industry, and residents themselves, followed by state, local and federal government entities.	[9]
	US (Oregon)	97% of County health officials surveyed – while concerned and knowledgeable about climate change impacts on health - do not consider climate change preparation (adaptation) as one of their top five priorities, mainly due to other health threats seen as more urgent, lack of financial and staffing resources, and lack of support from policy and decision makers.	[57]
	US (California)	A complex notion of responsibility for coastal adaptation emerged from focus group discussions with shorefront property owners: participants felt that individual protective actions are insufficient and detrimental to neighbors and a larger regional solution with government support (local, state, and federal) was required. Clearly climate change mitigation and adaptation were perceived as bigger tasks than individuals could take on. However, individuals were held responsible for being informed, politically engage, and make decisions for the common good.	[41, 42]
ADAPTATION TIMING: What attitudes do people express about when to adapt?	German Baltic Coast	Most respondents (regional decision-makers) viewed taking adaptation measures as "necessary" (on a scale from 1-7, not at all- very necessary), i.e. >56% judged them as 5 or higher. A majority judged these measures as needing to be taken sooner rather than later (on a scale from 1-7, immediately – sometime in the future), >59% judged them as a 3 or less.	[37]
	US and California	Vast majorities in California (85%) and nationally (82%) supported "preparation" (i.e., proactive adaptation) than a "wait and see" approach (13% and 16%, respectively). Support for preparation was almost equally high among coastal property owners as among coastal renters or inland dwellers.	[34, 35]
	US (Delaware)	The state-based survey found 56-61% of respondents believed that society should take immediate and drastic action to reduce the impacts of climate change (61%), that sea-level rise can be reduced by human efforts (59%), and that society should take immediate and drastic action to reduce the impacts of sea level rise (58%).	[9]
	US (Florida)	A wide range of stakeholders from government, business, environment, emergency management and infrastructure in coastal Florida – despite differences in agendas, interests, and preferences in adaptation strategies – could agree on improving hazard preparedness for current risks (hurricanes), but also to begin exploring additional adaptation strategies for the aggravated risks due to sea-level rise.	[58]
	UK (Wales)	Survey respondents narrowly favor mitigation over adaptation, but consider adaptation to	[14]

QUESTION	LOCATION	RESPONSES	REFERENCE
		already be a present need, with focus on managing flood risk a high-priority adaptation area for the government.	
ACCEPTABILITY OR PREFERENCE OF ADAPTATION OPTIONS: How are different response options perceived? Which are preferred?	The Netherlands	A majority (52%) of homeowners is willing to invest substantially in elevating their homes if the measure makes them safe from flood risk. They prefer the risk elimination option to risk insurance.	[59]
	The Netherlands	Approximately 2/3 of homeowners are willing to invest in water barriers in exchange for an insurance premium reduction; ca. 1/5 is willing to replace floor types that are vulnerable to flooding with water resistant floor types; and ~25% are willing to move central heating installations to floors safe against flooding in favor of a reduction in the insurance premium.	[60]
	UK	The acceptability of changing crops grown in response to climate change – as one adaptation options for farmers – depended on a wide variety of factors, incl. the existence of markets and good marketing facilities, co-benefits of the new crop (nitrogen fixing capacity), and ability to integrate the new crop into the farming system.	[61]
	France (Mediterranean coast; Sète de Lido)	Participatory approaches of framing, deliberating and evaluating adaptation responses to coastal erosion revealed that stakeholders preferred retreating coastal infrastructure and restoring the natural shoreline. A wide range of factors, not just cost and risk, contributed to the choice.	[62]
	United States	A national survey found majority support (extremely and very important) for measures taken to protect water supplies (62%), public health (62%), agriculture (62%), forests (57%), wildlife (58%), coastlines (52%), sewer systems (53%), and public property (47%).	[63]
	US (Rocky Mtn. region)	The greatest influence on residents' support for or opposition to forest management options to reduce wildfire risk was the current condition of the forest. Past experience with wildfire, forest proximity and use varied in their influence on opinions.	[64]
	US (Delaware)	Survey respondents "strongly" support the following adaptation options (in descending order of support): avoiding building new structures in areas at risk from sea level rise (67%), changing building codes and regulations to reduce risk in flood prone areas (63%), funding research (44%), using dredged material to build up marsh areas at risk (40%), elevating buildings using private funding (40%), (capital-intensive) building of dikes, seawalls, and bulkheads (33%), elevating land surfaces in areas at risk of sea-level rise (30%), allowing beaches and wetlands to naturally migrate inland (29%), using government funds to purchase land at risk of sea level rise (21%), to elevate buildings (18%), and to purchase frequently flooded properties (16%).	[9]
	US and California	A majority of Californians but fewer nationally thought adaptation would be good for the economy (52% vs. 38%) and create more jobs (60% vs. 42%). Few anywhere believed adaptation would be explicitly negative for the economy. When assessing support for	[34, 35]

QUESTION	LOCATION	RESPONSES	REFERENCE
		specific coastal adaptation options, the survey found similar levels of support in California and nationally: the most desirable option were stabilized sand dunes, followed by "induced retreat", Seawalls and sand replenishment. Local policies such as prohibiting rebuilding of storm-damaged structures, stronger building standards, and limits on new development found support by roughly half of respondents.	
	US (Virginia)	Focus group participants found educational materials, tools and online programs; likely to be most helpful in helping Hampton Roads prepare for sea-level rise. Special tax districts were believed to be most politically and economically feasible. Least likely to be accepted by the public were reasonable restrictions on development and rolling easements, and least socially acceptable were believed to be the use of transfer or purchase of development rights.	[65]
	US (Gulf Coast states)	76% of surveyed coastal residents support local government action to address the effects of climate change. Among the supporters, favored actions included maintaining freshwater supplies (94%), conservation of natural habitats (93%), protection of water supplies and wastewater against saltwater intrusion (90%), restoration of natural habitats (87%), increased funding for emergency planning (86%), modifying existing development to better resist flooding (84%), seawalls (82%), building elevation (73%), limiting certain structures in high-risk areas (71%), incentives to relocate (57%), and higher insurance rates (42%)	[8]
	Ghana, Afram Plains	The study examined the preferred adaptation strategies to floods and droughts among males and females in three communities, revealing some similarities but also significant differences related to the daily practices and different occupational responsibilities of men and women.	[66]
	Small Island Developing States (SIDS)	Migrating away from small islands – the cultural, ancestral and social homeland of island nations – is recognized as a potential necessity but widely opposed and not a desirable adaptation options.	[67, 68]
	Canada (Quebec, Gulf of St. Lawrence)	Coastal residents in the past have used mostly hard structures to protect against coastal erosion. For the future, they recommend using similar structures to fend against further erosion, and improved zoning laws. While mostly financed by property owners in the past (with limited government assistance), majorities in most communities view the federal and provincial governments as responsible for additional protective measures, or prefer cost-sharing arrangements.	[28]
	Australia (NE Arnhem Land)	Indigenous peoples' preferences for strategies to strengthen community adaptive capacity tended to be those that lead towards greater self-sufficiency, independence, empowerment, resilience and close contact with the natural environment.	[27]
	Australia	The majority of surveyed coastal residents believe that if seas are rising, it is more	[17]

QUESTION	LOCATION	RESPONSES	REFERENCE
		important to protect the beaches than private property, but those whose private properties would be directly affected by SLR either rejected the SLR risk, and/or expected to be able to hard-protect their land, receive government support for doing so, or be compensated in case of retreat. There are widely divergent views on the rights and responsibilities of private property owners. If risks of SLR are known prior to purchase, respondents considered it fair for owners to bear the risk and cost. Compensation for loss was key in making managed retreat an acceptable adaptation option	
	Bangladesh	Adaptation in situ is preferred over relocation, but for this to be effective, a range of additional initiatives must be established (e.g., establishment of safe shelter, community radio service and campaign for raising climate awareness).	[69]
EMOTIONAL RESPONSES TO ADAPTATIONS: What emotional responses do people express?	Australia	Angry responses from those rejecting climate change that retreat is even considered; blends with dismay that humans are considered causing climate change and with negative feelings about government; retreat option viewed as restraint on personal freedom. There is moral outrage against development in areas recognized as risky.	[70]
	Mozambique	Acceptability of relocation as an adaptation strategy for farmers was not accepted because farmers and policy-makers disagreed on the severity of flooding and drought (farmers showed lower concern for flooding but higher concern for recurring drought) and farmers were not included in deliberation of acceptable adaptation strategies. Farmers judged the adaptation to be worse than the risk, while policy-makers did not consider the negative impacts of the adaptation option at all.	[71]
	Latvia	About half of interviewed Latvian coastal residents affected by severe coastal erosion prefer hard shoreline protection and view it as an effective adaptation measure to coastal erosion. The other half does not support hard protection because of either long-term ineffectiveness or other undesirable consequences. Retreat as a strategy is acceptable for only a small number of interviewees.	[72]

References for Supplementary Material 2

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