

THE UNCERTAIN WORLD

The systemic risks, perceptions and implications of deep uncertainty: A Perspective from Bristol, the 2015 European Green Capital

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With Support from Hayley Shaw, the wider Cabot Institute Community and our Bristol, national and international partners

Summary

Thriving and prospering in the face of global uncertainty: An opportunity to transform our city and others

Human activity is causing our planet to warm and consequently the climate and environment are changing in unprecedented ways. Concurrently, our consumption and waste is exceeding capacity with respect to traditional food, water and energy resources, and approaching planetary limits. These changes represent direct and well documented challenges for our natural environment – as well as our society that is so crucially embedded within and dependent on that environment. They are also making our environmental future profoundly uncertain, uncertainty that will be manifested across a range of health, security and economic sectors.

Over the course of 2015, the year Bristol was the European Green Capital, the University of Bristol Cabot Institute explored the implications of these uncertainties for different people. Although global warming and its impacts are generally acknowledged as important societal challenges, uncertainty complicates long-term planning. It is often used as an excuse for inaction, and actions that are taken are based on weaker evidence and are, therefore, potentially inappropriate. This has profound global and national impacts as well as more direct impacts on the City of Bristol. This document explores how to mitigate that change and how to adapt to it, expressed as five “Emergent Principles”, which arose from and were modified by the thousands of conversations we had during 2015 with local governmental officials, members of the public, academics, business leaders, NGOs and youth leaders. The remainder of this document includes a discussion of the context and practicalities of our year long program, the knowledge this program elucidated, and an expansion of the emergent principles listed below.

Emergent Principles

- 1) **Minimize the behaviour that causes uncertainty:** Anthropogenic climate disruption is a source of profound uncertainty, not just to our weather but to our food, health and global security. This uncertainty is preventable, requiring reduction of carbon emissions in the short term, and the eventual cessation of emissions, probably by the middle of this century. This will be hard, as the burning of fossil fuels is pervasive in our society, but it will also create exciting new opportunities. There is a widespread ambition for cities to take the lead in this, but cities alone cannot achieve

carbon neutrality and will have to work with or drive other actors to deliver new financial, infrastructure and technological instruments.

- 2) **Radical Resiliency:** Even if global warming is limited to 2°C, Bristol can anticipate more intense heat waves, floods and enhanced exposure to infectious disease. However, it may be global food and economic volatility that cause greater impacts on Bristolians. Given the diversity of these risk factors and the deep uncertainty associated with all of them, classical risk management and preventative approaches must be supplemented with new forms of resiliency. Such resiliency will be based on empowered and resourced individuals and communities with the social, economic and material capacity to adapt; crucially this requires the minimizing of social, economic and political inequality. At its core, it will require flexible people, infrastructure, culture and regulation.
- 3) **System Change:** Climate change is part of a wider nexus of city challenges, including those related to health, inequality, nature, the economy and security. The combination of stresses requires a system-scale approach to future city planning and development.
- 4) **Common Cause:** It is essential to have a wider and more inclusive dialogue about climate change in order to incorporate local knowledge and culture and to generate political will to make challenging – or even unpopular – compromises. This should be done in a way that empowers local communities, including diverse social, ethnic and cultural groups, in order to ensure maximum engagement with new initiatives.
- 5) **Foundations for Transformation:** These challenges are opportunities for transformation and adaptation of the Future City. To enable the development of a sustainable thriving ecosystem within Bristol, we will need widespread support for change and strong, multi-level and mutually supportive political and community leadership. New tools for generating shared knowledge and building consensus will be essential.

Part I. Background and Context

'It has become clear that we are taking the planet into uncharted territory and changing the risk of extreme weather and climate events. Our exposure to these risks is also changing as a result of changes in how we live and a rapidly growing global population.' Dame Julia Slingo, Chief Scientist for the Met Office UK and Cabot Fellow, from her Cabot Institute lecture, February 3, 2015.

The Challenge of Environmental Uncertainty?

Uncertainty is the oft-forgotten, but arguably most challenging, consequence of mankind's centuries-long impact on the environment. Human civilization has sought to reduce environmental uncertainty for millennia, whether it be via wars or aqueducts, land management or trade agreements. Arguably, this is one of the defining features of the Anthropocene. But this trend has been reversed with the onset of climate change, extensive global pollution and dramatic depletion of the non-renewable resources that underpin our food, water and energy security.

This uncertainty has profound impacts on our decisions, planning and future. All of us, from individuals to councilors to prime ministers make decisions that are informed by experience. That includes our personal experiences, but also hundreds of years of observation that inform our predictions of future floods, drought, hurricanes and heat waves which in turn underpin decisions related to urban planning, agriculture and national security. Now, however, we are changing our environment and our climate, such that the lessons of the past have less relevance to the planning of our future.

'Society is facing an increasingly broad range of risks to our food, water and energy security, all of which are exacerbated by climate change. Decision makers must be able to understand not just what is likely to happen but also the reasonable worst case scenarios that could happen and for which we must be appropriately prepared.' – Sir John Beddington, Former Chief Scientific Advisor to the UK Government and Chair the Cabot Institute External Advisory Board.

2015 and the context of our events

During 2015, Bristol was the European Green Capital. Although a range of issues were examined, climate change was especially prominent due to our participation in the United Nations Climate Change Conference in Paris, or COP21, at the end of the year. That served as both a catalyst and an opportunity to reflect on the role that cities play in addressing climate change problems. In Paris, we played a major role in ensuring the formal and informal recognition that cities are essential to the climate change challenge, both in terms of accelerating emissions reductions beyond those of the Intended Nationally Determined Contributions (INDCs)ⁱ and bearing much of the burden in adapting to the climate change that does happen. Our city's primary COP21 contribution was co-hosting with Paris the Cities and Regions Pavilionⁱⁱ, facilitated by ICLEI (Local Governments for Sustainabilityⁱⁱⁱ). There, we provided leadership via our Transformative Action Plans^{iv} (TAP), which will be partly realized by the city's Framework for Climate and Energy Security. We also signed commitments to resiliency, an extension of our role as one of the Rockefeller Foundations 100 Resilient Cities, and led the Eurocities discussion around the role of smart technology in creating sustainable, resilient, healthy and fair, cities.

The Cabot Institute's 2015 theme of "*The Uncertain World*" explored the challenges of climate change uncertainty, as part of and contextualized by the Bristol's role as European Green Capital, as a Resilient City and as a Smart City, as well as in preparation for COP21.

The events

This *Uncertain World* conversation began during the middle of 2014 and spanned the entire Green Capital year. The first events included workshops on Living at the Sharp End of Environmental Uncertainty in Small Island States^v and on Communicating Uncertainty. During the year, it was discussed via the Bridging the Gap theme of the Bristol 2015 Opening Ceremony, the Youth, Business and Leaders' Summits and dozens of lectures and debates, jointly organized by Bristol 2015, the Cabot Institute and the Festival of Ideas. It has also been explored through reflections stimulated by the 2015 Arts Programme^{vi}. We have debated and discussed it all over the city, including during the Festival of Nature, Make Sundays Special events, Bristol Bright Nights and smaller events at local pubs. We have tried to explore how uncertainty impacts and complicates our lives but also new forms of engaging with it, such that it becomes a catalyst for positive change rather than an additional burden.



During the week of 17 Oct, this conversation peaked with the *Uncertain World* Summit, which featured public events at Hamilton House, a debate at the University and a 2-day workshop with leading thinkers. The Summit brought together diverse communities and examined environmental risks through the lens of this uncertainty and from a range of perspectives: those of Bristolians, some of whom were profoundly concerned with our environment and some of whom face more urgent challenges; those of business leaders trying to minimise risk in this *Uncertain World*; those of civil society and social enterprises trying to build resilient support networks; and those of academics seeking to provide useful interpretations of the knowns and the unknowns. We discussed and debated uncertainty associated with extreme weather events, floods and heat waves, sea level rise, food and water insecurity, refugee crises and regional conflict. We also discussed how these should inform Bristol's ambitions for the next 50 years and our contribution to COP21. This led to an exploration of the opportunities for leadership and innovation.



Her Excellency, Dame Pearlette Louisy, Head of State and Governor General of Saint Lucia, speaking at the Living at the Sharp End of Environmental Uncertainty Conference in Bristol, July 2014.



Conceptual Image of Withdrawn by Luke Jerrams; the actual installation was based in the National Trust Leigh Woods during the Summer of 2015

Among the contributors were thousands of public attendees; members of the Cabot Institute representing disciplines as diverse as climate science, environmental ethics and civil engineering; partners from the public sector, including Bristol City Council, the Environment Agency, the Met Office and the Ministry of Defense; partners from industry, including Bristol Water, Arup and DNV-GL; and partners from civil society including the Green Capital Partnership, Voscur and Ujima Radio. Issues of leadership were explored during a Question Time style event on 21 Oct featuring Bristol Mayor George Ferguson; Bristol Youth Mayor Neha Mehta; Peter Macfadyen, former advisor to Comic Relief and Mayor of Frome; Leo Hickman, Editor of the Carbon Brief; and Ann Cousins of Arup.

Part II. Elucidated Knowledge about Uncertainty

Here, we report the main emerging conclusions about perceptions, reactions and understanding of uncertainty elucidated during our year long series of conversations with many facets of the Bristol community. The lessons learned and articulated here are consistent with IPCC reports but take that conversation further to reflect on the challenges and opportunities Bristol faces in its preparation and commitments to COP21. Consequently, the catalyst for our conversation was climate change, which is especially relevant for the *Uncertain World* given the profound impact climate change is having and will increasingly have on environmental and social systems. We particularly noted the way that uncertainty has been manipulated to slow mitigative action, when in other circumstances such uncertainty would lead to bold action.



Although the remainder of this section focuses on climate change, climate change must be considered as part of a wider suite of environmental challenges that include, for example, pollution [highlighted during Bristol 2015 by growing concern with plastics in the sea and pesticides, and especially neonictinoids]; biodiversity loss [not just globally but in the UK countryside and in our cities]; and resource depletion and the wasteful behaviours that exacerbate that. Numerous participants argued that these issues caused them as great or greater concern than climate change. Moreover, many participants argued that although climate change might be a profound challenge – perhaps the defining challenge of the 21st century – almost all felt that its impacts are relatively distant in space and time compared to more urgent concerns related to the economy, health, inequality and security. This means that climate change initiatives will be more effective if they connect more directly to wider issues. This makes practical sense anyway as integrated policy solutions that simultaneously address sustainability and e.g. health or transport challenges will be more economical and efficient as well as more politically viable.

'Do we even live in a natural world anymore? Some form of farm or infrastructure covers or affects nearly all of our planet. We now, for better or worse, live in an engineered world.'

Professor Thorsten Wagener, Theme Leader for Water in the Cabot Institute

The following focuses on perceptions and understanding of climate change challenges, but we suggest that aspects of these observations will not only inform policy on climate change adaptation and mitigation but also serve as a template for discussing and debating other forms of environmental, social and economic uncertainty.

Perceptions of uncertainty

As with many previous efforts, our discussions revealed the complexity and diversity of perceptions of climate risks. We have argued that high uncertainty associated with some aspects of climate risk, especially those that impact food security, biodiversity vitality and health, compels action to cease carbon emissions as soon as possible; therefore, it was not surprising to hear similar comments echoed amongst our community. However, that represents only a part of the overall portfolio of opinions, many of which were compiled from our events and online via our Graffiti Wall. Statements ranged from those who argued that uncertainty means we should wait before investing in emissions reduction to those arguing that this is an excuse or even a manipulation of uncertainty. Others noted how they were uncertain about how climate change impacts them personally. In particular, the rather profound uncertainty associated with predicting local impacts, the impacts most relevant to our daily lives, distances the problem from individual decision making, sometimes leading to climate change being less of a concern than more immediate matters.

More nuanced opinions also emerged from our discussions. Many view the challenge of future uncertainty as an opportunity to reconnect with our values and redefine social structures in a more just, connected and harmonious way. Perhaps most intriguingly, some argued that uncertainty need not be a bad thing, that a fully certain world would be dull and lead to complacency.

Concurrent to the *Uncertain World* events, Cabot Institute academics edited a Special Volume of the Proceedings of the Royal Society on Uncertainty. This explored and elaborated on some of these themes: arguing that uncertainty should be a cause of mitigative action rather than a excuse for lack of action and showing that minimizing uncertainty via mitigation of global warming also minimized economic risk. Other work in the volume underscored that adaptation in an *Uncertain World* could be economically costly – as uncertainty increases, so does the probability that adaptive measures are inappropriate.



A selection of quotes offered for the Uncertainty Graffiti Wall during 2015.

A final component of our *Uncertain World* dialogue was conducted with RegenSW (and funded by the UK NERC). We asked 49 representatives from the renewable energy sector about their perceptions of climate change science, uncertainty and public attitudes. With respect to the primary rationale for renewable energy investment, the group was largely split between those who prioritise climate change mitigation (38%) and those who prioritise energy security. Nonetheless, a strong majority (82%) thought that experts should do more to explain climate science beyond academia, with a relatively even split amongst four potential target groups: the renewable industry sector, policy makers, the media and local communities. As expected from discussions at other events, perceptions on the importance of communicating climate change uncertainty were complex: most argued that scientists should talk more about uncertainty (63%) and nearly all argued that we must be honest about that uncertainty (89%). However, those surveyed were split as to whether communicating uncertainty was useful, as it remains complex and poorly understood by many. *Crucially, 65% of those surveyed were concerned about the uncertainty associated with climate change.*

Further insights into the perception and communication of climate science uncertainty are available in the Uncertainty Handbook^{vii}, by Steve Lewandowsky of the UoB Cabot Institute and Adam Corner of COIN.

Climate Uncertainty – What do we know and how well do we know it?

In our conversations we found that even in a city celebrated for being green and generally aware of environmental issues, there was a great deal of confusion over what the research community agrees on and what is still uncertain. This confusion existed in advocates for climate change action, as well as those opposed to action, creating a complex range of opinions on policy priorities. Therefore, we suggest that experts and the media be even more clear when discussing uncertainty, especially with respect to where there is uncertainty and where there is not, and that attempts to manipulate uncertainty be robustly rebutted. We found the following three points to be particularly useful in climate science uncertainty discussions.

(1) Perhaps most importantly, the Uncertain World is not one of which we have no knowledge.

Aspects of climate change for which we have robust understanding and low uncertainty should be the foundation, and often the preamble, for discussing all aspects of climate science^{viii}. We have high confidence that if greenhouse gas emissions continue, temperatures and sea level will rise, even though there is a probabilistic uncertainty in the magnitude of change. Given 'business as usual' emissions projections:

- The global temperature increase will likely be between 2.6 to 4.8°C by the end of this century.
- Heat waves will become more common
- Rainfall events will become more common and intense – even if specific regional rainfall forecasts are highly uncertain.
- Sea level rise will probably be between 0.45 to 0.82 m by the end of this century.
- The pH of marine surface waters will decrease by about 0.3 units.

In short, we understand many of the underlying controls on these aspects of the Earth system; our probabilistic forecasts are expressions of this mathematical, physical and chemical knowledge rather than ignorance.

However, the fact that outcomes for such key parameters can only be expressed as a range has significant implications for decision makers. Moreover, those ranges only represent probable outcomes. There is about a 1 in 3 chance that warming could be greater or lower than that likely range. There is

about a 1 in 3 chance that sea level rise could be higher (because of the nature of sea level rise risk, there is only a small chance that it is lower). The lower probability events lying beyond those 'likely' ranges could have devastating consequences but are rarely discussed or used to guide decision-making.

(2) We have a strong understanding of what is likely to happen on longer time scales due to our reconstruction of past environmental change (i.e. our knowledge is based on more than climate models and recent observations). Investigations of Earth history generally help to challenge and validate our understanding of the climate system as expressed in climate models, including confirming estimates of Earth system sensitivity (the amount of warming associated with a doubling of CO₂)^{ix} and showing that warmer climates are associated with a stronger hydrological cycle. But Earth history also provides additional perspectives. Crucially, it confirms the thousand-year lifetime of carbon dioxide in the atmosphere. This means that burning all of our available fossil fuels, even at a markedly reduced rate, still yields the possibility of 6°C or more of global warming, far exceeding the international agreement to limit warming to 2°C and the ambition to limit warming to well below 2°C. Earth history also reveals that the warming associated with INDCs (Intended Nationally Determined Contributions) will lead to warming between 2.7 and 3°C in this century and, without additional intervention, further warming in subsequent decades. And it shows that such warming will ultimately result in dramatic sea level rise. It has been argued that at least 1 m of sea level rise and perhaps as much as 4m is already 'locked in'. Warming of >3°C will result in the eventual melting of much continental ice and perhaps as much as ~70m of sea level rise. Although ice sheet changes are likely (but not proven) to be slow, occurring over hundreds or thousands of years, the consequences of such a long-term change on a coastal city like Bristol are profound.

(3) Beyond relatively well constrained uncertainty, profound (deep) uncertainty does persist and some of this uncertainty is irreducible. Although we do know that a warmer world will yield greater total rainfall (with more rain during storms and greater flooding), climate models differ with respect to which specific regions of the world will become wetter and which dryer. This is an uncertainty with profound social implications given our dependence on water not just for its own sake but also for food and energy. The challenge of deep uncertainty is particularly acute for wildlife, plants and the interdependency of organisms which define ecosystems. The impact of complex and synergistic effects of multiple stressors on the robustness and functionality of the biosphere is currently unknown and has potentially drastic consequences for life on the planet. Coastal ecosystems, for example, must adapt to rising temperatures, higher CO₂ concentrations, more acidic waters, increased nutrient concentrations and more oxygen depleted waters. It is difficult to determine how just one of those factors will affect a given organism let alone how the combined impact of all factors will affect the intertwined members of entire ecosystems. Our agricultural systems face a similar confluence of risk factors, such that the undermining of global food security is a profound risk and one that is associated with great uncertainty with respect to its timing and nature (i.e. will we experience deep and long-term food shortages or variable and unstable food supply with associated volatility in food prices?).

Underlying this uncertainty is the fact that current CO₂ levels of 400 ppm are higher than they have been for about the last 3 Million years^x. When the climate system 'catches up' to that CO₂ forcing, global temperatures will also be warmer than they have been for millions of years^{xi}. We are truly creating an *Uncertain World*, one that no human has ever experienced. Perhaps more concerning, although Earth has experienced high CO₂ levels in the past, the current *rate* of environmental change is almost entirely without precedent in the history of our planet, creating the potential for diverse uncertain consequences; for example, adaptive migration of species may not be feasible (especially when other factors, such as land use change, are considered). Although research can reduce this uncertainty, it can never fully eliminate all of it – some complexity is irreducible, some system-scale behavior is chaotic, and many aspects of climate-biosphere-geological interactions remain poorly understood.

As illustrated a recent special issue of *Philosophical Transactions of the Royal Society*^{xii}, such uncertainty has a vast range of economic, psychological and social consequences, ranging from inhibiting cooperation, stifling creativity and action and exacerbating economic risk. This means that the future is not just uncertain but the transition to it is likely to be volatile and messy, posing significant transition risks.

More concerning, however, is that these deep uncertainties represent systemic risks to our ecological, agricultural, social and economic systems. The geological record provides near-unequivocal evidence that climate change can cause profound disruption of biological and biogeochemical systems and even cause them to collapse – the definition of systemic risk. By extension, climate change represents a systemic risk to the social constructs dependent on these natural systems. These risks are finally being recognized by leaders and economic experts, including Mark Carney Director of the Bank of England^{xiii}.

The impact of climate change uncertainty on society

(1) Similar to ecosystems, social systems are incredibly complex and becoming more so due to myriad infrastructure, digital and demographic changes; extrapolating environmental impacts through such complex systems imposes additional uncertainty. The complexity of 21st century society is illustrated by our food security, which is a function of changing global demand, the impact of multiple environmental factors on plants and livestock, the depletion of nutrient, biodiversity and water resources (exacerbated by the uncertainty in rainfall forecasts), soil loss and the risks posed by pathogens. Due to the interconnected and globalized food production chain on which we depend, Bristolians are profoundly impacted by these issues even if they occur elsewhere on the planet; a food crisis in California could cause price and availability volatility here. This is only one example. Modern cities could be particularly vulnerable to numerous unforeseen or difficult to anticipate consequences, ranging from the impacts of floods on traffic and the local economy to the impact of heat waves on health services. Without more sophisticated approaches to understanding the complexity of modern cities and their response to both natural and human interventions, it is difficult for citizens and leaders to predict outcomes and plan accordingly. This underscores arguments that climate change will not only challenge this and future generations but poses systemic risks to them.

(2) Climate change and climate change uncertainty exacerbates other societal challenges. Even though the impact of climate disruption on social systems is complex, it is likely to be profound, negative and inequitable^{xiv}. Heat waves and floods, especially if unpredictable, have strong health and mental health impacts. These have been studied by the EA^{xv} but <10% of the UK's Local Health Authorities have considered these issues in their sustainability planning (as of end-2015; The Bristol LHA has considered this). Additional health impacts likely arise from the impact of drought on food price volatility and subsequent impacts on food deprivation. A large number of UK citizens live in a state of food deprivation, but robust statistics are lacking making it difficult to estimate how climate change will exacerbate this issue.^{xvi} The economic impacts of climate change have also been documented extensively; more recently the Pope's encyclical on climate change has highlighted its impact on inequality and poverty. Climate change, as documented in numerous studies and illustrated by other natural and human-exacerbated environmental disasters, disproportionately affects poor nations and poor populations in rich nations. For this reason, the University of Bristol Townsend Centre for International Poverty Research directly supported strong climate action at COP21. Finally, climate change has long been argued to likely exacerbate refugee crises, with recent work revealing its contribution to the Syrian crisis^{xvii}.

(3) Climate change and environmental degradation concern many UK citizens but they are not the major concerns for most of them. A recent YouGov Poll commissioned by the Bristol Cultural Development Partnership revealed that the top five concerns of UK citizens^{xviii} living in cities were overcrowding, health services, congestion, loss of green spaces and poverty/income inequality. Although climate change is related to these issues, the topic itself scored relatively low in the survey across a range of demographic groups. Similar results have been obtained by Quality of Life surveys in Bristol. Making strong political, corporate and individual decisions is difficult when those decisions address impacts perceived to be far away and in the far future (as articulated by George Marshall, COIN, in the Cabot Annual Lecture, Nov 2015). However, many of the issues that dominate UK citizens' concerns will be exacerbated by climate change, revealing the lens through which climate change

discussions should progress. Climate change is a threat, and a particularly uncertain one, to our health, our security and our jobs.

III. Guiding Principles for Bristol Action

Arising from the previous reflections, we propose the following guiding principles for climate action. We have chosen not to present these as a Framework, given the importance of addressing these challenges in the context of wider and more diverse concerns; instead, we propose these as principles against which other policies can be tested. Moreover, given the prominent role of cities in driving carbon emissions faster than INDCs, we suggest that Bristol, and especially as a centre of high tech and innovation and the only UK city to be chosen as European Green Capital, should pursue a particularly aggressive agenda.

A. Reduce then Stop Emissions: We fully endorse the internationally agreed ambition to limit global warming to 1.5°C^{xix}. We further argue that the uncertainty associated with predicting Earth system behaviour – or more precisely, the uncertainty caused by our carbon emissions – creates social and economic systemic risk, instability and insecurity, and that should drive us to stronger mitigative (as opposed to adaptive) policies. We also agree with numerous statements, including the University of Bristol's Townsend Centre for International Poverty^{xx} submission to COP21 and Pope Francis' Encyclical on Climate Change^{xxi}, that limiting climate change is a moral imperative due to its disproportionate impact on the poor as well as its impact on the other 8 million species on Earth. The unequal impacts have been acutely illustrated for Bristolians, with an Environment Agency study showing that deprived areas in Bristol are generally more exposed to flood risk.

Although targets have been shown to be politically vital, we argue for a more positive narrative: e.g. ***“The challenge of reducing the impacts of climate change creates a profound opportunity to reshape society: making our cities healthier, more prosperous and more livable.”*** This sentiment of opportunity was the most frequently articulated comment at our events and reveals the emerging cultural desire for system change. Climate change action need not drive economic stagnation and social misery, and in fact, could create new jobs, industry and opportunities for prosperity. The scale of that effort, however, must not be underestimated. It will be hard. To avoid dangerous climate change and limit global warming to 2°C requires the reduction of greenhouse gas emissions by about 40% over the next 15 years, deep reductions by 2050 and a near 100% reduction by 2065. Bristol has formally agreed the first two targets (40% reduction by 2025 and 80% reduction by 2050), and at COP21 Mayor George Ferguson – on behalf of a cross-party coalition, including current Mayor Marvin Rees – pledged to increase that ambition and be carbon neutral by the middle of this century. We endorse those ambitions.

Failing to hit these targets and consumption of all known fossil fuel reserves could lead to warming as high as 6°C, while exposing us to energy insecurity as supplies dwindle. The agreed emission targets discussed above require new policies, strategic investment and behaviour change, and ultimately they will require new technology. We urge Bristol leaders to support these ambitions by engaging at three levels.

1. Leaders can catalyse change for environmental and economic benefit to achieve >40% emissions reductions by 2030. The Cabot Institute commissioned Bristol Professor Andy Gouldson (now at Leeds) to conduct a mini-Stern review on Low Carbon Cities for Bristol^{xxii}; this report shows that Bristol can achieve >40% emissions reductions and achieve economic benefit by investing in energy efficiency. However, those opportunities will require up-front investment and must be catalysed and supported by both city and community leaders.
2. Bristol can achieve 80% emissions reductions by 2050, but this will require an even greater degree of cooperation and compromise. Transport, for example, will have to be transformed, and our electricity will have to be supplied nearly entirely via renewables – as

will domestic heat. This will likely require national support via, for example, investment in public transport and the energy grid but local initiatives and incentives such as district heating remain vital.

3. The near-complete emissions reductions suggested for 2065 (or sooner) cannot be achieved by Bristol alone. Complete emissions reduction will require new technologies in, for example, waste recycling, supply chains and energy storage.

In short, the long-term need for near-complete emissions reductions will require our city leaders, community activists and wider civil society to work together, to support and catalyse action of universal benefit, to agree and compromise over challenging issues and to demand with a unified voice the wider interventions that will allow full carbon neutrality. We fully endorse the COP21 ambitions that cities be empowered to pursue emissions targets beyond those of the national commitments. However, we urge these new efforts to shift the focus from solving the single challenge of carbon neutrality to embedding climate action in deeper cross-cutting policies that also address challenges of inequality, health and well-being.

B. Radical Resiliency: Cities, due to their complexity, population density and interdependence with the rest of the world, will be strongly impacted by future climate change. The Paris Agreement effectively concedes a significant global warming of around 2°C (and actual policies fall far short of that). Bristol will have to adapt to at least some climate change impacts, as well as those associated with other environmental issues, including pollution, disrupted food production and biodiversity loss. The most likely direct climatic impacts in the UK, including Bristol, will be more frequent and intense heat waves and flooding. However, it is likely that a confluence of additional factors, will result in food price volatility, exacerbating food deprivation and consequent impacts on health. It is also likely that more global challenges, including the economic and security impacts of climate change, will affect Bristol. Bristol is an ethnically and culturally diverse city, with >91 languages spoken and at least 45 religions; it is also a City of Shelter and is committed to supporting refugees displaced by disaster.

The future world, therefore, will not just be warmer with more floods, but will also be more volatile, uncertain and economically and socially unstable. Profound uncertainty challenges classical risk management approaches which are based on experience and historical records and the forecasts derived from them. Such approaches will remain useful but must be complemented by a radical expansion of the concept of resiliency in planning and policy. This is being explored by the Bristol City Council's Resilience Group^{xxiii}, funded and supported via Bristol's role as one of the Rockefeller Foundation's 100 Resilient Cities. Although in progress, that group's conclusions broadly agree with those emerging from systems perspectives and climate research in Cabot: not all system shocks can be predicted - or perhaps more accurately, an unmanageable plethora of shocks can be imagined – and that means that resiliency must be fluid and flexible. It will become less predictive and more anticipatory. To be resilient, will require a city that is adaptive, one that can evolve with a changing climate and urban landscape. A tangible example of this is constructing buildings with reusable components or roads and railways that have room to evolve, growing, changing function or disappearing^{xxiv}. This adaptive mode must not only be deeply embedded in infrastructure and city support services but also in individuals and communities, and in policies, laws and regulations.

Achieving such resiliency will be a challenge, but it can be an opportunity if we are creative and adaptable. It will also be critical to rapidly share the lessons that such creativity reveals. Strong social cohesion, more local power and resource, and more connected and stronger communities appear to be vital to ensuring this resiliency. We must build more adaptable infrastructure and we must liberate not just our creativity but our children's capacity to act on it, avoiding enacting policies or agreements that will limit their options and flexibility. A key component will be community access to experimentation, data and knowledge and hence both the Bristol Brain and Bristol is Open could be major assets. Other important assets will be access to locally-owned energy production, community food projects, upcycling and localized manufacturing capacity. Finally and perhaps most fundamentally, resolving inequality in all of its forms, from inequalities of income, wealth and power to the digital divide, will be essential.

“The 21st century has spawned a special glossary of terms to describe surprising catastrophes: black swans, dragon kings, unknown unknowns etc. How might we be better prepared to cope with such extreme rare events, and be surprised less?” Gordon Woo, RMS (from his Cabot Institute presentation in 2015)

C. System Change: Climate change impacts will likely manifest across a range of sectors, from health to labour to infrastructure. Similarly, many of the costs of sustainable action will be offset or even repaid by gains in other sectors, e.g. savings in the health services, economic growth and improved quality of life via improved transport networks.

‘Climate change already affects human health, through malnutrition, the impacts of extreme weather events, and the geographical reach of some diseases, but carbon reduction policies can be perceived to be in tension with development policies. Policies for transport, energy, food and agriculture, housing and health sectors could have benefits for both health and the environment.’ Professor Andy Haines, Chair of the Lancet-Rockefeller Foundation Commission on Planetary Health, from his Annual Lecture to the University of Bristol Centre for Research in Health and Social Care, School of Policy Studies.

Therefore, it is crucial for our future leaders to embed consideration of sustainability issues and climate impacts into all their decision making processes, i.e. the sustainability of health care provision. We also strongly support the emerging consensus (see Foresight Future City Report; GO-Science) that cities adopt whole-system decision-making structures and strategies; by extension policy makers will need to have the power and incentives to make such System-level changes. Institutions will better manage this more *Uncertain World* if they can break down decision-making silos, develop holistic policies and support the technological and social innovations that address cross-cutting issues of sustainability, resilience, health, biodiversity, prosperity and social justice. While this appears monumental, and the cultural shift is large, procedurally this will be far more cost effective and efficient. An excellent example is how cycling and walking, rather than driving, is a simple act which acts across human to global scales to holistically improve our lives: it improves the mental and physical health of the non-driver, improves air quality, improves social connectivity, reduces stress and health care costs, and reduces congestion and global warming. Moreover, targeting improved health is more tangible and immediate to most people than climate change. Thus, many of the costs of improving access to human powered transport are offset by gains in other sectors. *We therefore posit, that instead of viewing climate change and sustainability as goals, environmental challenges be viewed as methods to achieve a more just, vibrant and healthy landscape.* By extension, we should draw discussion of these topics out of the environmental news ghetto (as highlighted by Jonathan Porritt in his Green Capital lecture), and embed them in the wider and more diverse public dialogue.

D. Common Cause: We cannot assume that even in our Green Capital, climate change is a top concern; to many people it is not. To many others, it is a huge but poorly understood, frequently abstract concern. Therefore, public dialogue about climate change must continue, although this dialogue must evolve. It must engage a wider audience, involve a wider range of advocates (i.e. religious leaders, businesses, security forces, trade unions), invite in all of Bristol's communities and adopt new and perhaps surprising narratives. We suggest that to invite wider engagement on the topic, fora should be created in which diverse groups can propose their own agendas and action plans to reach city wide goals based on broad principles. This approach would be particularly appropriate for drawing together diverse cultural, ethnic, religious and class groups. It is not sufficient to simply invite such communities to discussions or engage with a select few representatives; these groups have much to offer and should be given the space and voice to help drive the dialogue and policy development.

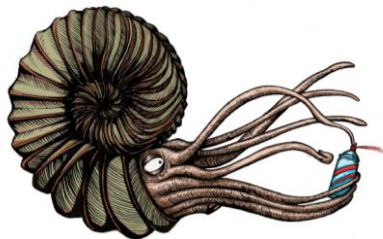
E. Foundations for Transformation. These climate, sustainability and resilience challenges are profound opportunities for transformation and adaptation of our Future City, but this will require widespread support and strong political leadership – and not just strong leadership ‘at the top’ but distributed leadership across the city. In this time of increasing social complexity and environmental

uncertainty, solutions will be controversial and compromises will be necessary. Experimentation and innovation – and by extension, trust among the diverse agents in Bristol – will be required. We suggest that this will require new forms of local governance, engagement and finance^{xxv}. Broadly, this is consistent with or even requires a strong devolution settlement, which should allow more freedom to experiment and greater capacity for system change, but local issues should remain aligned with national and global goals, opportunities and consequences: the best way to become resilient is for all of us to become resilient. To achieve this, we support a dialogue across the entire city and with diverse communities to ensure that a breadth of perspectives and evidence can inform the decisions we make in the coming decades, while engaging and exciting the populace to create their own opportunities to flourish in the face of an Uncertain World.

Sponsors and Thanks:



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Other Potential Figures:

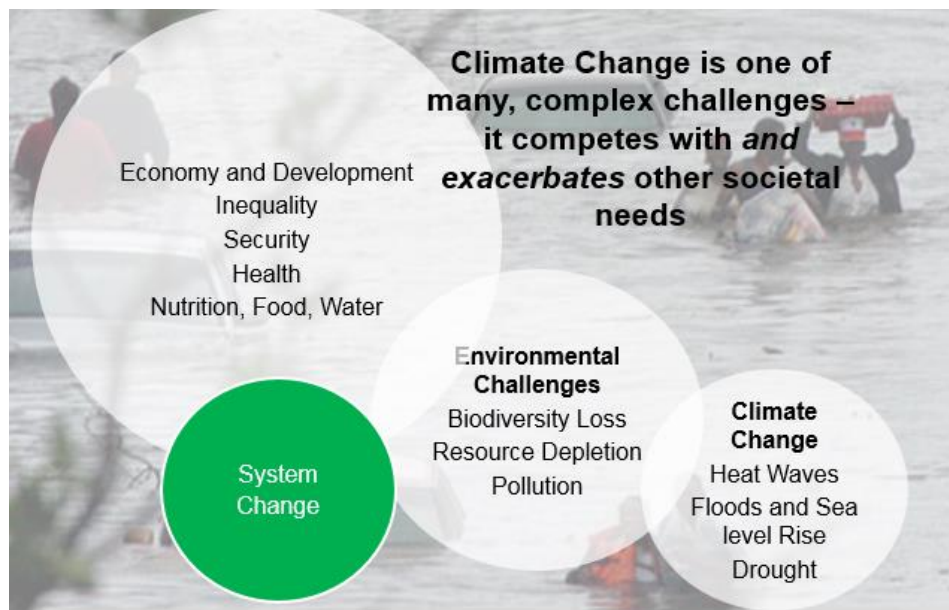


Figure 2. Climate change is part of a wider suite of societal challenges and addressing it requires an integrated, system-scale approach that also addresses (and generates financial advantages from) other sectors, such as health and economic development.



Figure 3. An ethical rationale for tackling climate change

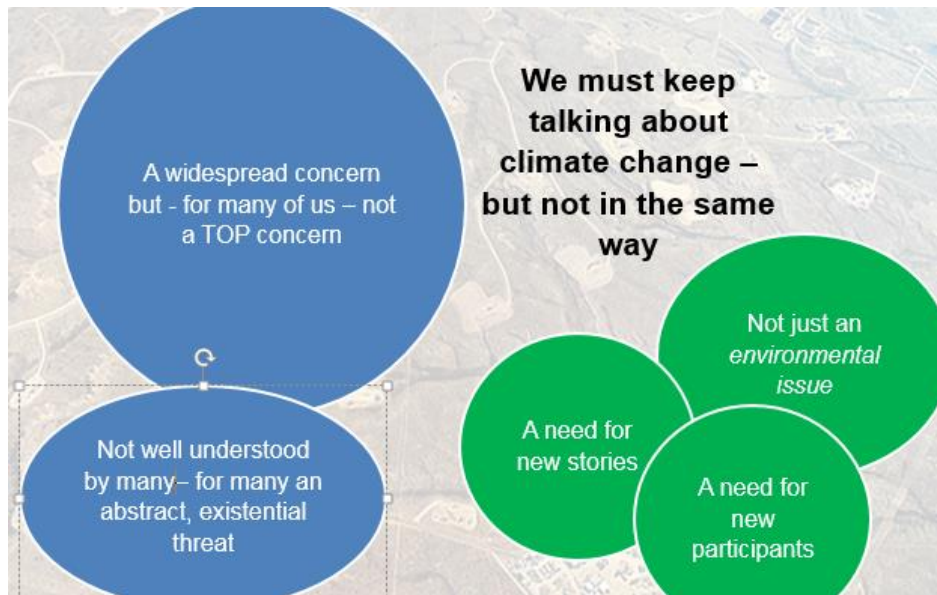


Figure 4. How can climate risks be communicated in a manner that motivates faster and broader action?

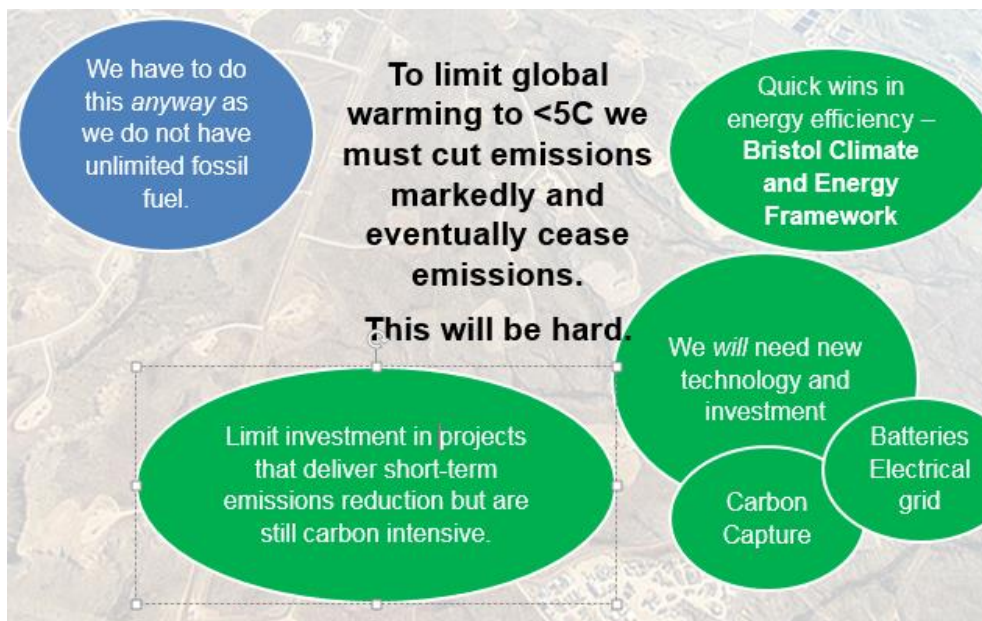


Figure 5. The challenge of carbon neutrality. We must achieve quick wins in emissions reductions now but we must also start investing in the new technology and infrastructure that will underpin the more challenging emissions reductions of the future.

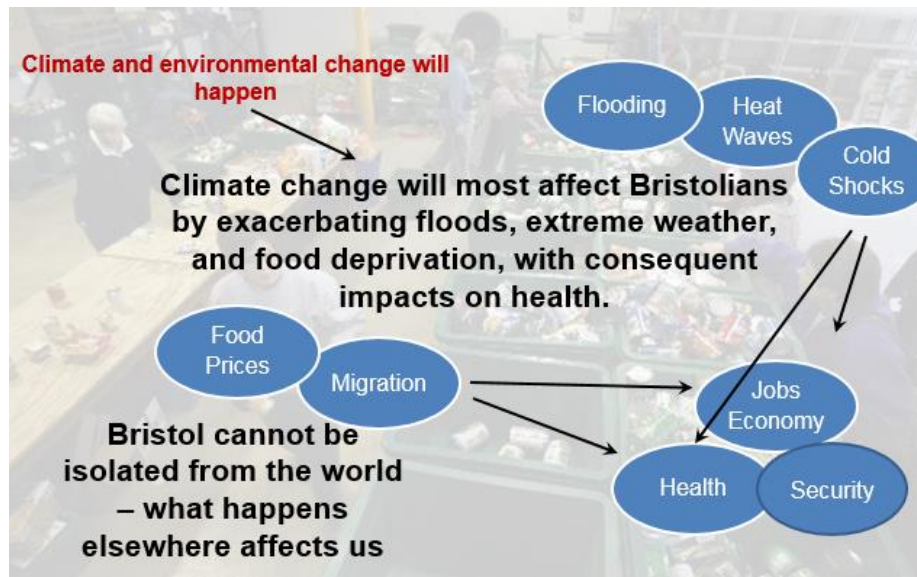


Figure 6. What are some of the likely consequences of climate change for Bristolians?



A rethinking of resiliency. We must accept that given profound uncertainty and complexity that not all disasters can be prevented; instead, we need more creative and empowered resilient agents who can manage and mitigate the impacts of our environmental challenges.

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- i <http://www.wri.org/indc-definition>
- ii <http://www.cities-and-regions.org/>
- iii <http://www.iclei.org/>
- iv <http://tap-potential.org/about-tap/>
- v <http://www.bristol.ac.uk/education/events/2014/1002.html>
- vi Including Withdrawn, the Fog Bridge, Fourthland's Public Dreaming and prehistoric animal street art by Alex Lucas (see Figure 1).
- vii <http://climateoutreach.org/resources/uncertainty-handbook/>
- viii <http://climateoutreach.org/resources/uncertainty-handbook/>
- ix For example, see our recent paper on Pliocene climate:
<http://www.nature.com/nature/journal/v518/n7537/full/nature14145.html>
<http://www.bbc.co.uk/news/science-environment-31131336>
- We note, however, that these findings are consistent with several previous studies of ancient CO₂-temperature relationships across a range of timescales.
- x <http://www.nature.com/nature/journal/v518/n7537/full/nature14145.html>
<http://www.bbc.co.uk/news/science-environment-31131336>
[10.1016/j.epsl.2010.01.037](http://www.nature.com/nature/journal/v518/n7537/full/nature14145.html)
- xi Recently, Cabot Institute researchers highlighted that the particular warmth of the Pliocene was evident not only in mid-latitude and polar regions but also in the tropics. Such a finding emphasises how pervasive the global warming was under these elevated CO₂ levels. [10.1038/NGEO2194](http://www.nature.com/nature/journal/v518/n7537/full/nature14145.html)
- xii <http://rsta.royalsocietypublishing.org/content/373/2055>
- xiii <http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx>
- xiv Intergovernmental Panel on Climate Change Working Group 2
- xv <https://www.gov.uk/government/publications/climate-change-health-effects-in-the-uk>
- xvi IPCC Working Group 2
- xvii Kelley CP, Mohtadi S, Cane MA, Seager R and Kushnir Y (2015) Climate Change in the Fertile Crescent and implications of the recent Syrian drought. Proceedings of the National Academy of Sciences 112, 3241-3246. DOI: 10.1073/pnas.1421533112
- xviii <http://www.ideasfestival.co.uk/blog/festival-of-the-future-city/new-research-reveals-british-attitudes-to-cities/>
- xix <https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>
- xx <http://www.bristol.ac.uk/poverty/>
- xxi http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html
- xxii <http://bristol.ac.uk/cabot/media/documents/bristol-low-carbon-cities-report.pdf>
- xxiii <http://www.100resilientcities.org/cities/entry/bristols-resilience-challenge#/- />
- xxiv McDonough, W. and M. Braungard, *Cradle to Cradle*, 2002, North Point Press
- xxv <http://cabot-institute.blogspot.co.uk/2015/09/delivering-future-city-does-bristol.html>