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# Extended impacts of climate change on health and wellbeing Felicity

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Abstract Anthropogenic climate change is progressively transforming the environment despite political and technological attempts to reduce greenhouse gas emissions to tackle global warming. Here we propose that greater insight and understanding of the health-related impacts of climate change can be gained by integrating the positivist approaches used in public health and epidemiology, with holistic social science perspectives on health in which the concept of ‘wellbeing’ is more explicitly recognised. Such an approach enables us to acknowledge and explore a wide range of more subtle, yet important health-related outcomes of climate change. At the same time, incorporating notions of wellbeing enables recognition of both the health co-benefits and dis-benefits of climate change adaptation and mitigation strategies across different population groups and geographical contexts. The paper recommends that future adaptation and mitigation policies seek to ensure that benefits are available for all since current evidence suggests that they are spatially and socially differentiated, and their accessibility is dependent on a range of contextually specific socio-cultural factors.

1. Introduction In 2008, the World Health Organisation’s (WHO) World Health Assembly adopted a resolution urging Member States to take decisive action to address the health impacts of climate change. Yet despite being one of the most recognised contemporary and future global environmental issues, the effects and repercussions of rapid changes in the climate for diverse aspects of human lives have received surprisingly little attention. Here we begin by contextualising climate change within the broader background of recent environmental and demographic transformations. We then consider how current questions of climate change have been framed within a health-related context. While enormous progress has been made by epidemiologists, modellers and others working from a more quantitative, positivist perspective, we suggest much could also be learned by adopting a holistic approach to health that seeks to more explicitly encompass the concept of human wellbeing. This, we argue, would enable fuller consideration of some of the more subtle, secondary health-related impacts of climate change, and provide insight into what can be learned from current climate change adaptation and mitigation strategies, and from initiatives seeking to produce co-benefits to human health and the environment. Key here is recognition of the need to evaluate

both the benefits and disadvantages of climate change adaptation and mitigation strategies in relation to health and wellbeing, and to explore the diversity of experience and unintended consequences of such interventions across and within different socio-cultural environments. The paper recommends that future adaptation and mitigation policies seek to ensure that benefits are available for all since current evidence suggests that they are spatially and socially differentiated, and their accessibility is dependent on a range of contextually specific socio-cultural factors.

2. Climate change and health in context Anthropogenic climate change since the 1970s is reported to have claimed over 150,000 lives and 5.5 million Disability Adjusted Life Years (DALYs) per year (Patz et al., 2005; Haines et al., 2006). Future projections by the Intergovernmental Panel on Climate Change indicate that climate change will exacerbate existing health problems over the coming decades (Collins et al., 2013). Heatwaves, fires, under-nutrition, lost labour productivity, the spread of food, water and vector-borne diseases and higher incidences of climate-related, non-communicable disease pose mounting challenges, particularly to those within vulnerable groups, such as the poor, children, the elderly and the infirm (Smith et al., 2014; Luber et al., 2014; Balbus and Malina, 2009). Whilst not wishing to downplay the importance of climate change on health, it is important to view it in context. For example, environmental pollution was identified earlier as one of many health threats. Indeed, in the 1950–60s it was considered to be the major environmental threat to humans, and it is currently still very significant. There is mounting evidence for example, that the cocktails of chemicals used in industrial processes, the agricultural sector, and even the healthcare sector, are entering ecosystems (Redshaw et al., 2013). Contamination of air, water, food and the materials we are in contact with (clothing, furnishings) leads to the accumulation of body burdens of pollutants that may be associated with changing incidences of disease such as diabetes, cardiovascular disease and cancers (Depledge et al., 2013; Gennings et al., 2012). Similarly, there are those who argue that biodiversity loss and the associated impacts on ecosystem services constitutes the key threat to human health and wellbeing in the 21st Century (Cardinale et al., 2012). Many other examples could be cited including concerns over food and water security, and the repercussions they may have for human health, both physically and psychologically. It is important to recognise that all of these environmental threats are exacerbated by rapid, anthropogenic climate change (Collins et al., 2013). As well as marked changes in the global environment, major increases in the size and distribution of the World's population are taking

place, and a growing ageing demo-graphic means that the future population who will have increased exposure to environmental threats will be, on average, older, and potentially less resilient and able to adapt (Gamble et al., 2013; Hajat et al., 2014). Climate change is therefore happening in an era in which simultaneous changes in the global environment and in human demography are occurring, and these changes can, in various contexts, act together to magnify health impacts (Haines et al., 2006). This leads to two assumptions: first, the wide range of environ-mental triggers for health effects increases the uncertainties involved in predicting outcomes for humans; and secondly, the likely magnification of impacts makes the need to develop effective health strategies for adapting to or mitigating climate change more pressing.

3. Established approaches to understanding health and climate change Whilst recent years have seen the climate change debate move beyond a purely environmental agenda, it is important to recognise that a positivist, quantitative approach has held precedence in discussions concerning climate change and health. This has likely been a necessary strategy to enable epidemiologists and those working in the field of public health to demonstrate evidence of the serious effects of climate change and to attract popular and policy interest in, and support for, key issues. However, the very nature of the methods required to elicit and analyse the large-scale data that tends to characterise this type of research, coupled with the extensive knowledge that has accumulated on the environmental impacts of climate change, means that certain issues have received the majority of the attention to date. In particular, considerable attention had been placed on issues relating to threats from excessive heat, inundation (water), air pollution (gases and particulates) and the spread of infectious diseases. This has several important implications: first, limiting our understanding of climate change-related health impacts to those that come about as a result of severe storms, flooding, heatwaves and a limited range of environmentally-associated infectious diseases (e.g. malaria, cholera, dengue), has meant that many other important health effects, whilst often acknowledged (see for example, Smith et al., 2014; McMichael, 2013; McMichael and Lindgren, 2011), continue to remain under-investigated. The latest IPCC Working Group II Report chapter on health (see Smith et al., 2014) expands the focus of attention towards a wider set of issues than has previously been the case – perhaps most notably those relating to climate change impacts on economic activity. Yet it is still the case that the obvious, acute, adverse health-related impacts of climate change are obscuring the more complex, insidious, secondary effects that might damage or subtly alter the lives of many more people

worldwide. Although direct effects on morbidity and mortality include those resulting from severe weather events, the largest effects on global health are likely to come from the indirect impacts of climate change, such as changes to the availability of water, food and shelter and the shifting range of vector-borne infectious diseases (Costello et al., 2009; Smith et al., 2014). Perhaps most of all however, some of the largest – but more subtle, secondary impacts on people’s daily health may in fact come about via climate change influences on human behaviour and lifestyle choices and also via mechanisms intended to underpin climate change mitigation or adaptation measures. Examining these kinds of issues requires a broader approach that extends discussions of climate change and health to incorporate the concept of wellbeing.

4. Incorporating wellbeing into climate change and health debates In recent years a new body of literature exploring how to achieve positive mental health or ‘wellbeing’ has gained increasing momentum across a range of academic and applied settings (Atkinson et al., 2012). Such work offers an approach that is more in line with the holistic WHO definition of health; namely an approach that sees health as ‘a state of complete physical, mental, and social wellbeing, and not merely the absence of disease or infirmity’ (WHO, 1946). The subjective nature of wellbeing and a lack of clarity over the meaning of the term means that it is interpreted in multiple ways, but it can be broadly categorised as a ‘positive mental state enhanced and supported by various social, environmental and psychological factors’ (see DEFRA, 2007). The indistinct and unstable meanings of the term impact upon the ways in which wellbeing is conceptualised and ‘quantified’ (see White et al., 2012), and is perhaps one of the key reasons why until relatively recently, it has received little attention in the context of climate change. What is increasingly clear is that climate change can seriously threaten wellbeing. In its most blatant form, adverse impacts on wellbeing can be viewed through the lens of mental ill-health. WHO predicts that by 2030, depression will be the most widespread health problem on the planet, in the top three of all cause morbidity, in all continents (WHO, 2011). While this is of course not due only – or even primarily, to climate change, living with and adapting to the changing environmental will result in more stressful circumstances for many people. The reported suicide of over 200,000 Indian farmers in the previous two decades for example, is thought to be in part explained by recent climate change adversely impacting their livelihoods (Vasavi, 2012; Grue`re and Sengpta, 2011; Renton, 2011), while flooding in the UK has been associated with increased levels of post-traumatic stress (Carroll et al., 2009; Tunstall et al., 2006). Issues relating to mental health are

becoming increasingly recognised within climate change literature (see for example, Smith et al., 2014), but there remains considerable scope for more in-depth empirical research to initiate evidence-based action in this area (Berry et al., 2010). At the same time, a more holistic definition of wellbeing involves consideration not only of mental ill-health, but also recognition of the benefits that can be gained through securing positive mental health. Such an approach enables us to start asking questions which examine for example, how changes in weather patterns influence levels of outdoor and social activity crucial for health and positive feelings of wellbeing (Townsend et al., 2003) and to recognise that adverse changes in the local environment, especially if sudden, can adversely impact subjective feelings and emotions (Doherty and Clayton, 2011). At the same time, it is important to pay cognizance to the potential health and wellbeing issues that may arise if the environment is constantly presented to us as a threat. How, for example, might this affect children's relationships and (dis)engagement with the natural environment and the health and wellbeing benefits it can offer? And how – and importantly, why – these kinds of issues may then manifest in forms of physical and mental ill-health, are just some of the key issues that necessitate attention in future research, and may be best addressed via a range of both qualitative and quantitative methodologies. Studies that consider these kinds of questions are now gaining some ground within the broader environment–society literature, and have significant value for those concerned with climate change-and health debates. Climate change and wellbeing have for example, begun to be considered as closely inter-related issues in government strategies within some countries and contexts, and indirect positive wellbeing outcomes are being incorporated into climate change governance strategies. In the UK for example, local government sustainable development policy (e.g. DEFRA, 2005) has included the 'Sustainable Communities: Building for the Future' Plan, which focused on increasing quality of life through the provision of a safe, healthy and green environment, and a diverse, vibrant and creative local community, while at a national scale, the Singapore National Parks Authority seeks to tap in to and promote the health and wellbeing benefits that are afforded by the environments that it maintains (Brown and Bell, 2007). Within this work, a key focus has been on the wide range of benefits – or 'co-benefits' that can be afforded through adaptation and mitigation initiatives that seek to reduce green-house gas emissions whilst simultaneously promoting health and wellbeing (Haines et al., 2009; Smith and Haigler, 2008). However, it is vital to recognise that climate change adaptation and mitigation strategies can have both positive and negative implications for health and wellbeing, and that such experiences can be socially and spatially differentiated. The remainder of this paper

examines the current context within which health-related climate change adaptation and mitigation strategies are enacted, and, drawing on research with which the authors are currently involved, demonstrates how approaches that incorporate the notion of wellbeing can provide deeper insight into climate change impacts on health.

5. Current health-related climate change adaptation and mitigation Mitigation and adaptation are well-established concepts used in contemporary climate change research. Mitigation is understood to involve pre-emptive strategies to avoid climate change, whilst adaptation connotes responses to the changes and impacts of climate change through modification of existing systems (Pelling, 2011). Yet concepts of health-related adaptation and mitigation have only recently begun to be more widely acknowledged in public health literature and policy. One reason for this is that many research and policy communities working on climate change are said to be working through a siloed, rather than a cross-cutting multi-sectoral approach (Lynch et al., 2008). Climate change and health are often the responsibility of different departments, and this may have provoked reluctance amongst some key public health decision-makers to prioritise climate change within the health sector. This in turn has significantly affected both the resources the health sector receives and its progress in current and future mitigation and adaptation (Syal et al., 2011). Very little of the funding available through the UN Framework Convention on Climate Change for adaptation initiatives for example, is currently being invested in health protection activities (Smith et al., 2014; Bowen and Friel, 2012), and what has, has been narrowly channeled towards individual health issues such as malaria (Manga et al., 2010). Indeed, a recent review by the World Health Organisation estimated that commitments to health adaptation globally amount to under 1% of the annual health costs attributable to climate change in 2030 (WHO Regional Office for Europe 2013). At the same time, while a number of adaptation and mitigation measures have been successful in preventing or alleviating poor climate change-related health outcomes (Smith et al., 2014), public health efforts still commonly focus more on reactive measures to cope with environmental stressors than on long-term adaptation measures per se (Wolf et al., 2010). This points to the importance of research and policy agendas that seek to ensure that health professionals and the public that they serve are more climate change literate, not only to help push for adequate and sustained levels of mitigation and adaptation-oriented funding (Abelsohn et al., 2013; Portier et al., 2010), but also to ensure that strategies adopted effectively respond to the health and wellbeing needs of diverse population groups.

6. Assessing co-benefits – and recognising dis-benefits As discussed, it is increasingly recognised that there are opportunities to achieve co-benefits from actions that seek to reduce the harmful emissions of climate altering pollutants and at the same time, improve human health and wellbeing. Milner et al. (2012) for example, emphasise how housing energy efficiency impacts upon urban air quality, thermal comfort, and associated wellbeing, and has co-benefits associated with reductions in certain types of chronic disease. Others have pointed to the joint benefits afforded by policies that promote cycling and walking over motor vehicle use in cities (Younger et al., 2008). The benefits of urban green – and increasingly blue (water) – space for health, wellbeing and climate change mitigation and adaptation are also now receiving attention. Urban green space is associated with cleaner air, a reduction of the heat-island effect and a reduction in vehicular transport use and has been considered alongside broader sustainable development strategies in relation to transport, housing and green space, in which ‘green’ outcomes can have health and wellbeing co-benefits (Rydin et al., 2012). White et al. (2013) report a positive relationship between green space and self-reported wellbeing, a finding confirmed in research reporting positive links between green space, improved mental and social well-being, and increased physical activity (Hartig, 2008; De Vries et al., 2003). An emerging body of literature also points to the array of environmental, health and wellbeing benefits of blue space in urban areas (Balaban and Puppim de Oliveira, 2013). From a policy perspective, there are signs that in some areas, such holistic approaches that incorporate broader notions of wellbeing are starting to have some influence. In the UK for example, Natural England (2010) has focused on the value of green space in urban areas, emphasising the importance of ‘Nature Nearby’ for health, wellbeing and climate change mitigation, whilst in Colombia, integrated policies in the capital city, Bogota, have led to the weekly closure of 120 km of roads to cars, resulting in marked improvements in levels of air pollution, physical activity and social cohesion (Sarmiento et al., 2010; Cervero et al., 2009). Yet it is important to recognise that the co-benefits of climate change adaptation and mitigation measures are likely to have spatially and socially differentiated impacts. Rather than just viewing poor health outcomes as an inevitable impact of climate change therefore, we can develop understanding of how impacts and measures to alleviate or mitigate these at one scale may influence or disrupt health and wellbeing outcomes at other scales. This can be demonstrated by Beijing’s transport policy changes around the 2008 Olympic Games, where, in an effort to produce acceptable air quality, traffic control measures were introduced through car ownership and use reduction initiatives. There were intended and unintended consequences of these policies across a



variety of spatial and societal scales. Globally, the pace of climate change was potentially reduced very slightly as a result of the Beijing initiatives, and locally, levels of air pollution were alleviated (Zhou et al., 2010), leading to respiratory health benefits for the urban population during the time of the Olympics (Worden et al., 2012). And at an individual level, it is possible that physical fitness and feelings of wellbeing may have improved as people were encouraged to seek alternative forms of transport such as cycling or walking. On first reflection, this all seems to point to a series of positive environmental and health-related outcomes, and it is this kind of uni-linear approach that forms the framework for much of the current climate change and health co-benefits research. However, if we take a holistic approach to consider the impacts of such policies on people's daily lives and lived experiences, we may well find that the picture is far less clear, and that the more obvious health benefits are in fact destabilised by a range of more subtle—but significant, challenges to human wellbeing. What for example, if as a result of long-term car reduction policies, people struggle to access work, child-care or green space for leisure? Research has for example, shown that car use is associated with positive wellbeing, providing freedom, independence and ontological security to car users (D'Ambrosio et al., 2012; Ellaway et al., 2003; Hiscock et al., 2002). Similarly, what does it mean for important social capital networks if such policies mean that people are less able to visit friends and relatives, and what does it mean for peoples' connectivity with natural environments – and the health and wellbeing benefits that such settings provide, if people now struggle to leave the city? We can start to see therefore that any health assessment of a climate change reduction policy quickly becomes both highly complex and subject to large uncertainties, and that the balance between addressing climate change and protecting physical and mental health and wellbeing is not easily achieved. Issues around climate change are not as simple as just promoting adaptation and/or mitigation strategies and there are numerous consequences of such actions that need to be far better understood. As Adger (2003:388) says, “decisions on adaptation [to and mitigation of climate change] are made by individuals, groups within society, organizations, and governments on behalf of society. But all decisions privilege one set of interests over another and create winners and losers.” Understanding how such decisions are made, and how they can most effectively be made to ensure positive outcomes across different social groups is surely a key question that we should be striving to answer in future climate change and health debates.

7. Adaptation, mitigation and social justice Work that examines the health-related impacts of adaptation and mitigation strategies is currently being examined in two studies in which the authors are involved. The first, URGENCHE (Urban Reduction of GHG Emissions in China and Europe) is an EU funded programme bringing together an interdisciplinary team of internationally recognised scientists from a variety of institutions, both academic and policy focused. The team are working in five European cities (Rotterdam, Stuttgart, Kuopio, Basel, Thessaloniki) and two Chinese cities (Xi'an and Suzhou) to develop and implement an assessment framework to examine both positive and negative health and wellbeing impacts of greenhouse gas (GHG) reduction policies and to develop models that can then be applied elsewhere. Part of this project has involved examining the impacts of various climate adaptation and mitigation policies on different social groups. Policies that simultaneously reduce GHG emissions and traffic noise for example, have been found to have a particularly important health benefit for people from lower socio-economic back-grounds, since they often live close to busy roads and have poor quality housing. The other, Outdoor Cities, is concerned with understanding how 'green' co-benefits strategies to encourage sustainable transport, expand green and blue space, and promote its use, impact on the health and wellbeing of city residents from different socio-economic backgrounds. Initial analysis of qualitative research undertaken for this project in Copenhagen, Denmark suggests that the impact of such strategies is influenced by a range of socio-cultural and economic factors. Importantly, findings suggest that it is helpful to understand how such strategies are perceived and understood by those they are targeted towards, and to examine the wider socio-cultural connotations associated with such initiatives. Considerable emphasis has for example, been placed on implementing policies with environmental and health co-benefits in Copenhagen. Yet the study found that residents often associated these policies with a particular kind of lifestyle that was difficult for people from lower socio-economic groups to achieve. As such, these residents were less likely to benefit from the health and wellbeing opportunities inherent within such initiatives despite policy claims of universal advantage. Understanding the health consequences of climate change and the outcomes of strategies seeking to provide co-benefits is also therefore a matter of social justice. It is well recognised that low-income populations tend to be the most adversely affected by poor health outcomes – and existing socio-economic inequalities are very likely to continue to constrain the adaptive capacity of poor people (Huang et al., 2011; UN-HABITAT/WHO, 2010). Even within high-income countries, events such as Hurricane Katrina have illustrated vividly how the poorest people, and often correspondingly, those from black and minority ethnic groups,

can be especially vulnerable to the health risks brought about by climate change (Brodie et al., 2006; Elliott and Pais, 2006), whilst others have stressed the gendered dimensions of these issues, and emphasised the ways in which women from low-income households, can face specific health-related vulnerabilities and constraints to adaptation (WHO, 2012). More concerted efforts are needed therefore to identify those communities and vulnerable groups whose health is increasingly at risk, and who are already experiencing the adverse health effects of climate change. These groups are in a sense ‘canary communities’ – those who will, like canaries in a mine, provide early warning of dangers. Importantly, detailed vulnerability assessments and in-depth epidemiological and social research within such communities is also needed to provide insights into possible health-related consequences of climate change, and to identify vital indications relating to effective coping, mitigation and adaptation strategies that can be supported through targeted interventions and funding. Progress here requires better understanding of the various contextually specific socio-cultural factors implicated in adaptation and mitigation processes. We do not currently understand in sufficient depth the socio-cultural and cognitive factors that facilitate pathways to sustainable human behaviour, or conversely, that create barriers. In a globalising world, cultural differences in worldviews amplify the challenges of overcoming such barriers and generating responses that reinforce sustainable behavioural patterns. Future research in this area must attend critically to the diverse, spatially contingent outcomes of climate change strategies, rather than make assumptions of the same outcome for all. This approach encompasses broader issues, including socio-cultural factors such as employment, education and access to health services, and also reinforces the need to be attentive to issues of equality and justice. Acknowledging socio-cultural factors would also afford opportunities to develop more local, contextually relevant work, taking into account spatial and scalar difference and recognising the diverse ways in which the environment can influence socio-cultural interactions.

**Conclusions** Understandings of the relationship between climate change and health have progressed and expanded considerably in recent years. This paper however, has argued that there is value in extending this discussion even further to adopt a more holistic approach to health that more explicitly encompasses the concept of wellbeing. Such an approach enables us to start looking beyond the most obvious and immediate health-related outcomes of climate change, to also consider the more subtle yet insidious secondary outcomes that impact upon people’s everyday mental health and wellbeing. Climate change mitigation and sustainable development goals are often framed in terms of collective responsibilities,

governed across a broader scale to wellbeing, which is a predominantly individualised concept. There remains much potential therefore for critical attention to the multiple temporal and scalar governance strategies in which wellbeing is incorporated into climate change policy. In particular, this paper has highlighted the potential for spatially differentiated impacts of climate change adaptation and mitigation strategies, and has emphasised the need for further research to understand more fully both the diverse benefits and the adverse outcomes of such policies for health and wellbeing across different socio-cultural and spatial settings. Examining the differentiated effects of governance strategies, and the spatial and scalar complexity and nuances of policy outcomes, will enable better understanding of the impacts of climate change on people's everyday health and wellbeing and provide a more informed context within which issues of equality and justice can be addressed.

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## r e f e r e n c e s

- Abelsohn, A., Rachlis, V., Vakil, C., 2013. Climate change: should family physicians and family medicine organizations pay attention? *Can. Fam. Physician* 59 (5) 462–466.
- Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. *Econ. Geogr.* 79 (4) 387–404.
- Atkinson, S., Fuller, S., Painter, J., 2012. *Wellbeing and Place*. Ashgate, Farnham.
- Balaban, O., Puppim de Oliveira, J.A., 2013. Understanding the links between urban regeneration and climate-friendly urban development: lessons from two case studies in Japan. *Local Environ.*, accessed online (19.12.13) at <http://dx.doi.org/10.1080/13549839.2013.798634>.
- Balbus, J.M., Malina, C., 2009. Identifying vulnerable subpopulations for climate change health effects in the United States. *Int. J. Occup. Environ. Med.* 51, 27–33.
- Berry, H.L., Bowen, K., Kjellstrom, T., 2010. Climate change and mental health: a causal pathways framework. *International Journal of Public Health* 55, 123–132.
- Bowen, K.J., Friel, S., 2012. Climate change adaptation: where does global health fit in the agenda? *Global Health* 8 (10) .
- Brodie, M., Weltzien, E., Altman, D., Blendon, R.J., Benson, J.M., 2006. Experiences of Hurricane Katrina evacuees in Houston Shelters: implications for future planning. *Am. J. Public Health* 96 (8) 1402–1408.
- Brown, T., Bell, M., 2007. Off the couch and on the move: global public health and the medicalisation of nature. *Soc. Sci. Med.* 64 (6) 1343–1354.
- Cardinale, B.J., Duffy, E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., et al., 2012. Biodiversity loss and its impact on humanity.

Nature 486, 59–67. Carroll, B., Morbey, H., Balogh, R., Araoz, G., 2009. Flooded homes, broken bonds, the meaning of home, psychological health in a disaster. *Health Place* 15, 540–547. Cervero, R., Sarmiento, O.L., Jacoby, E., Fernando Gomez, L., Neiman, A., 2009. Influences of built environments on walking and cycling: lessons from Bogota. *Int. J. Sustain. Transportation* 3, 203–226. Collins, M.R., Knutti, J., Arblaster, J.L., Dufresne, T., Fichefet, P., Friedlingstein, X., Gao, W.J., Gutowski, T., Johns, G., Krinner, M., Shongwe, C., Tebaldi, A.J., Weaver, Wehner, M., 2013. Long-term climate change: projections, commitments and irreversibility. In: Stocke, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom/New York, NY, USA. Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Puppim de Oliveira, J.A., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J., Patterson, C., 2009. Managing the health effects of climate change. *Lancet* 373 (9676) 1693–1733. D'Ambrosio, L.A., Coughlin, J.F., Pratt, M.R., Mohyde, M., 2012. The continuing and growing importance of mobility. In: D'Ambrosio, L.A., Coughlin, J.F. (Eds.), *Ageing America and Transportation: Personal Choices and Public Policy*. Springer Publishing, New York, pp. 11–27. DEFRA., 2005. *Securing the Future: Delivering the UK Sustainable Development Strategy*. DEFRA, London. DEFRA, 2007. *Common Understanding of Wellbeing for Policy*. DEFRA, London. Depledge, M.H., Tyrrell, J., Fleming, L.E., Holgate, S.T., 2013. Are marine environmental pollutants influencing global patterns of human disease? *Mar. Environ. Res.* 83, 93–95. De Vries, S., Verheij, R.A., Groenwegen, P.P., Spereuwenbery, P., 2003. Natural environments – healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environ. Plann. A* 35 (10) 1717–1732. Doherty, T.J., Clayton, S., 2011. The psychological impacts of global climate change. *Am. Psychol.* 66 (4) 265–276. Ellaway, A., Macintyre, S., Hiscock, R., Kearns, A., 2003. In the driving seat: psychological benefits from private motor vehicle transport compared to public transport. *Transportation Res. Part F: Traffic Psychol. Behav.* 6 (3) 217–233. Elliott, J.R., Pais, J., 2006. Race, class, and Hurricane Katrina: social differences in human responses to disaster. *Soc. Sci. Res.* 35 (2) 295–321. Gamble, J.L., Hurley, B.J., Schultz, P.A., Jaglom, W.S., Krishnan, N., Harris, M., 2013. Climate change and older Americans: state of the science. *Environ. Health Persp.* 121 (2) 15–22. Gennings,

C., Ellis, R., Ritter, J.K., 2012. Linking empirical estimates of body burden of environmental chemicals and wellness using NHANES data. *Environ. Int.* 39 (1) 56–65. Grue` re, G., Sengpta, D., 2011. Bt cotton and farmer suicides in India: an evidence-based assessment. *J. Dev. Stud.* 47 (2) 316–337. Haines, A., Kovats, R.S., Campbell-Lendrum, D., Corvalan, C., 2006. Climate change and human health: impacts, vulnerability and public health. *Public Health* 120, 585–596. Haines, A., McMichael, A.J., Smith, K.R., Roberts, I., Woodcock, J., Markandya, A., Armstrong, B.G., Campbell-Lendrum, D., Dangour, A.D., Davies, M., Bruce, N., Tonne, C., Barrett, M., Wilkinson, P., 2009. ‘Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers’, *Lancet*, 374(9707): 2104-2114 Hajat, S., Vardoulakis, S., Heaviside, C., Eggen, B., 2014. Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020 2050 and 2080. *J. Epidemiol. Commun. Health* 68, 641–648. Hartig, T., 2008. Green space, psychological restoration, and health inequality. *Lancet* 372 (9650) 1614–1615. Hiscock, R., Macintyre, S., Kearns, A., Ellaway, A., 2002. Means of transport and ontological security: do cars provide psychosocial benefits to their users? *Transportation Res. Part D: Transport Environ.* 7 (2) 119. Huang, C., Vaneckova, P., Wang, X., Fitzgerald, G., Guo, Y., Tong, S., 2011. Constraints and barriers to public health adaptation to climate change: a review of the literature. *Am. J. Prev. Med.* 40 (2) 183–190. Luber, G., Knowlton, K., Balbus, J., Frumkin, H., Hayden, M., Hess, J., McGeehin, M., Sheats, N., Backer, L., Beard, C.B., Ebi, K.L., Maibach, E., Ostfeld, R.S., Wiedinmyer, C., Zielinski- Gutie` rrez, E., Ziska, L., 2014. In: Melillo, J.M., Richmond, Terese (T.C.), Yohe, G.W. (Eds.), *Human Health. Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, pp. 220–256, <http://dx.doi.org/10.7930/J0PN93H5> (Chapter 9). Lynch, A.H., Tryhorn, L., Abramson, R., 2008. Working at the boundary: facilitating interdisciplinarity in climate change adaptation research. *Bull. Am. Meteor. Soc.* 89, 169–179. Manga, L., Bagayoko, M., Meredith, T., Neira, M., 2010. Overview of Health Considerations within National Adaptation Programmes of Action for Climate Change in Least Developed Countries and Small Island States. WHO, Geneva. McMichael, A.J., 2013. Globalization, climate change, and human health. *N. Engl. J. Med.* 368 (14) 1335–1343. McMichael, A.J., Lindgren, E., 2011. Climate change: present and future risks to health, and necessary responses,. *J. Intern. Med.* 270, 401–413. Milner, J., Davies, M., Wilkinson, P., 2012. Urban energy, carbon management (low carbon cities) and co-benefits for human health. *Curr. Opin. Environ. Sustain.* 4, 398–404. Natural England, 2010. *Nature Nearby: Accessible Natural Greenspace Guidance*. Sheffield: Natural England. Available online at:

<http://publications.naturalengland.org.uk/file/95015> (online 08.11.13). Patz, J.A., Campbell-Lendrum, D., Holloway, T., Foley, J.A., 2005. Impact of regional climate change on human health. *Nature* 438, 310–317. Pelling, M., 2011. *Adaptation to Climate Change: From Resilience to Transformation*. Routledge, London. Portier, C.J., Thigpen Tart, K., Carter, S.R., Dilworth, C.H., Grambsch, A.E., Gohlke, J., et al., 2010. A Human Health Perspective on Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Environmental Health Perspectives/National Institute of Environmental Health Sciences, Research Triangle Park, NC, <http://dx.doi.org/10.1289/ehp.1002272>, Online: [www.niehs.nih.gov/climate-report](http://www.niehs.nih.gov/climate-report) (accessed 15.11.13). Redshaw, C.H., Stahl-Timmins, W.M., Fleming, L.E., Davidson, I., Depledge, M.H., 2013. Potential changes in disease patterns and pharmaceutical use in response to climate change. *J. Toxicol. Environ. Health B: Crit. Rev.* 16 (5) 285–320. Renton, A., 2011. India's Hidden Climate Change Catastrophe. *The Independent*, 2nd January 2011. Accessed online (06.11.13) at <http://www.independent.co.uk/environment/climate-change/indias-hidden-climate-change-catastrophe-2173995.html>. Rydin, Y., Bleahu, A., Davies, M., Davila, J.D., Friel, S., De Grandis, G., 2012. Shaping cities for health: complexity and the planning of urban environments in the 21st century. *Lancet* 379 (9831) 2079–2108. Sarmiento, O., Torres, A., Jacoby, E., Pratt, M., Schmid, T.L., Stierling, G., 2010. The ciclovia-recreativa: a massrecreational program with public health potential. *J. Phys. Act. Health* 7 (Suppl. 2) S163–S180. Smith, K.R., Haigler, E., 2008. Co-benefits of climate mitigation and health protection in energy systems: scoping methods. *Annu. Rev. Publ. Health* 29, 11–25. Smith, K.R., Woodward, A., Campbell-Lendrum, D., Chadee, D., Honda, Y., Qiyong Liu, Q., Olwoch, J., Revich, B., Sauerborn, R., 2014. Human Health: Impacts, Adaptation, and Co-Benefits. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Accessed online (25.07.14 at <http://ipccwg2.gov/AR5/report/>). Syal, S.S., Wilson, R.S., Crawford, J.M., Lutz, J., 2011. Climate change and human health—what influences the adoption of adaptation programming in the United States public health system? *Mitigation Adapt. Strategies Global Change* 16 (8) 911–924. Townsend, M., Mahoney, M., Jones, J.-A., Ball, K., Salmon, J., Finch, C.F., 2003. Too hot to trot? Exploring potential links between climate change, physical activity and health. *J. Sci. Med. Sport* 6 (3) 260–265. Tunstall, S.M., Tapsell, S., Green, C., Floyd, P., George, C., 2006. The health effects of flooding: social research results from England and Wales. *J. Water Health* 4, 365–380. UN-HABITAT/WHO 2010. *Hidden Cities: Unmasking and Overcoming Health Inequities in Urban Settings*.

WHO/UNHABITAT, Kobe/Nairobi. Vasavi, A.R., 2012. Shadow Space: Suicides and the Predicament of Rural India. Three Essays Collective, Gurgaon, Harayana. White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H., 2013. Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychol. Sci.* 24, 920–928. White, S.C., Gaines, S.O., Jha, S., 2012. Beyond subjective wellbeing: a critical review of the Stiglitz Report approach to subjective perspectives on quality of life. *J. Int. Dev.* 2496, 763–776. WHO, 1946. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19–22 June, 1946, signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, No. 2, p. 100) and entered into force on 7 April 1948. WHO 2011. Global burden of mental disorders and the need for a comprehensive, coordinated response from health and social sectors at the country level: Report by the Secretariat, Accessed online (5th September 2014) at [http://apps.who.int/gb/ebwha/pdf\\_files/EB130/B130\\_9-en.pdf](http://apps.who.int/gb/ebwha/pdf_files/EB130/B130_9-en.pdf). WHO, 2012. Mainstreaming Gender in Health Adaptation to Climate Change Programmes. WHO, Geneva. WHO Regional Office for Europe, 2013. Climate Change and Health: A Tool to Estimate Health and Adaptation Costs. WHO, Copenhagen. Accessed online (01.08.14) at <http://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/publications/2013/climate-change-and-health-a-tool-to-estimate-health-and-adaptation-costs>. Wolf, J., Adger, W.N., Lorenzoni, I., Abrahamson, V., Raine, R., 2010. Social capital, individual responses to heat waves and climate change adaptation: an empirical study of two UK cities. *Global Environ. Chang.* 20, 44–45. Worden, H., Cheng, Y., Pfister, G., Carmichael, G.R., Zhang, Q., Streets, D.G., Deeter, M., Edwards, D.P., Gille, J.C., Worden, J.R., 2012. Satellite-based estimates of reduced CO and CO<sub>2</sub> emissions due to traffic restrictions during the 2008 Beijing Olympics. *Geophys. Res. Lett.* 39 (14). Younger, M., Morrow-Almeida, H.R., Vindigni, S.M., Dannenberg, A.L., 2008. The built environment, climate change, and health: opportunities for co-benefits. *Am. J. Prev. Med.* 35 (5) 517–526. Zhou, Y., Wu, Y., Yang, L., Fu, L., He, K., Wang, S., Hao, J., Cen, J., Li, C., 2010. The impact of transportation control measures on emission reductions during the 2008 Olympic Games in Beijing, China. *Atmos. Environ.* 44 (3) 285–293.