Health Climate Change impacts report card technical paper

10. Climate change and health in the UK. Scoping and communicating the longer-term "distal" dimensions.

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Executive Summary

Reflecting a traditional environmental health approach, efforts to communicate the health and wellbeing impacts of climate change have tended to emphasise the more proximal impacts that, for the public and policymakers, appear near in time and space and are more readily understood. Yet there is a wider set of climate-related health and wellbeing impacts which can seem remote for public and policy communities, if indeed they are recognised at all. This paper reviews diverse sets of evidence from public health and climate impacts studies across climate science, hydrology, agriculture and the economic and social sciences. We present a conceptual model of proximal and distal impacts of climate change, relating ecosystem services to health and wellbeing outcomes. We argue that this model can be deployed as a framework for thinking about climate and health and for communicating the outputs of that thinking to an often disengaged public and policy constituency. We focus on the reasons why significant risks associated with global and regional scale impacts appear distal and highlight selected mechanisms, notably population migration and threats to food security. The analysis demonstrates that the warming planet and its consequences have significant importance for health and wellbeing in any locality, even if they can appear very distant in space and time. We argue that only by communicating the true extent of the proximal and distal health and wellbeing risks can the appetite and commitment be engendered for mitigation of and adaptation to, the climate threat.

Key Messages

- *When considering the impacts of climate change for health and wellbeing in any location, including the UK, it is important to take account of threats from changes to the environment which are proximal (near in time and space and readily understood) but also more "distal" adverse health impacts driven by climate-related ecological disruption and its consequences*.

- *If the so-called "distal pathways" from climate change to health and wellbeing become more widely understood, this will lend further impetus and urgency to climate change mitigation and adaptation agendas.*

- *Despite their potential significance, estimating the scale of health and wellbeing impacts is challenging due to the complicated interaction of social economic and physical factors. There is also inevitable uncertainty over the effectiveness of the societal/global response to a warming planet.*

- *High priority should be given to new initiatives that account for and enhance communication about both the proximal and distal pathways by which climate change impacts health and wellbeing.*

- *A new environmental conceptualisation of public health is now required which recognises vastly expanded temporal and spatial scales, and distal as well as proximal causes. Conceptual models hold significant potential as tools with which to think, communicate and assemble evidence in relation to both the proximal and distal impacts of climate change on health.*

Introduction

The effects of global climate change are now observable in every part of the world. Scientific assessments suggest that nowhere on this planet will be immune to its future threats to human health and well-being (IPCC WG2 2014). The recent report of the International Panel on Climate Change (IPCC) Working Group 2 (WG2) on impacts, adaptation and vulnerability (IPCC WG2 2014) makes it clear that humans are being put a risk, directly and indirectly, by climate change. For example, changes in temperature and precipitation, and the resultant more frequent and severe heatwaves, droughts, floods and fires, all present direct localised health risks where they occur. However, of at least comparable concern for any country or location, are the many indirect or distal adverse health impacts driven by climate-related ecological disruption and its consequences. Thus crop failures or shifting patterns in disease vectors elsewhere, or indeed references to future sea-level rise can often appear remote. Yet any sense of security engendered by physical or temporal separation can be illusory. These distal effects of climate change matter for all economies and social-ecological systems. They emerge not only from the physical and ecological changes across the globe, but also from the societal responses such as geographic and social displacement of populations in conditions of prolonged drought, or of severe and persistent flooding. Everyday behaviours and lifestyles, as well as health and social inequalities, will be affected (Thomas et al, 2014).

Our focus in this paper is on the health and wellbeing impacts of climate, and specifically what we define as the distal pathways. Our aim is to better understand how these issues can be effectively scoped and communicated in the present, given the many complex interactions (including geographic and temporal distance) which underpin them. However, we are aware that, despite its potentially devastating consequences, climate change is but one amongst many societal challenges emerging from the interconnected impacts of global environmental change. Addressing all such challenges requires that we identify and gain support for actions which simultaneously protect both ecosystem and human health and wellbeing, in ways which are socially inclusive, sustainable and equitable, globally and across multiple generations.

The paper is framed as a consideration of the health impacts of climate change in the UK and there is periodic reference to the UK context. However, the themes discussed and the messages which emerge have generic relevance for all countries considering the health threat from climate change.

Climate change as a public health issue

Over and above its status as a major environmental issue, dealing with the consequences of climate change is increasingly framed as a public health challenge (Griffiths et al, 2009; Rayner and Lang, 2012). In seeking solutions, the necessity to form partnerships amongst many disparate actors and to employ crosscutting interdisciplinary and transdisciplinary approaches also speaks to the traditions and aspirations of public health, only now on a global scale (UCL- Lancet, 2014)

Global environmental change, including climate change, first engaged public health interest in the late 20th century (e.g. Haines & Fuchs (1991); Chivian (1993); McMichael (1993; 1994); Epstein et al,(1993); Kovats et al (1999). In the UK, the public health discourse on climate change centred, initially at least, on the local and immediate implications of flooding and extreme weather (Department of Health, 2002). Presenting these largely overt, proximal" or obviously direct and often localised health threats from climate (impacts which are near in time and space) is more convincing as, for most people, the near term and lived experience of climate change is, or will be, related to encountering changes in weather patterns and extremes. These manifestations, and their implications for health and wellbeing, can be widely understood and addressed in part by local responses, adding a sense of urgency to adaptation and mitigation efforts. Experiencing abnormal weather also influences the perceptions of climate change (Howe and Leiserowitz, 2013). Indeed, there is empirical evidence that personal exposure to severe flooding alters the perceptions of responsibility towards more enthusiasm for tackling energy use as a cause of climate change (Whitmarsh, 2008).

Distal stressors and their effects

We adopt the term distal, to describe those more remote, often indirect, pathways by which climate change can affect health and wellbeing.. Such pathways are often mediated by natural systems (e.g. disease vectors, water-borne diseases, air pollution) and by human systems (e.g. occupational impacts, under-nutrition, and mental stress) (IPPC WG2, 2014). Importantly, they are often linked to the longer term, so-called creeping, impacts of ecosystem and natural resource change.

The essential nature of a distal pathway, in the meaning here, is challenging to define. Pathways to health and wellbeing appear distal, usually for a combination of three reasons.

Many pathways can appear *"temporally distal"* because the true extent and gravity of their impacts on health and wellbeing will be felt only with time, perhaps after decades or even generations. The environmental changes which lead to such impacts are difficult to discern especially in the average: regional temperature change; rainfall intensity and aggregates; reduced snow and ice coverage; increasing ocean acidity; and raising sea levels. All have the potential to affect health and wellbeing, often adversely, to a degree which depends not only on the future emission trajectory, but also on the success of adaptive responses. Uncertainty, compounded by a limited understanding of how these (often incremental) changes predicted with the highest confidence can be important for their nation's health and wellbeing, mean that policy makers and the public are often much more concerned over flooding, storms and heatwaves than about widespread, insidious global warming.

Sea level rise is a very obvious example of a temporally distal pathway for a country such as the UK, even for those who embrace it as a real prospect. Most can conceptualise what it might mean for society, the economy and health, but it still seems far down the line and remote. What might be termed "temporal discounting" is clearly a barrier to be overcome when seeking to engage the public and policy makers. Ocean acidification is another excellent example of a temporally distal

pathway - caused by ocean absorption of CO_2, which in turn is chemically converted into carbonic acid, gradually lowering ocean pH. The long term impacts from this change in pH on the chemical composition of marine organisms results in changes in fertility and growth (as well as changes in the behaviour of many chemicals in acidic marine waters), are unknown, as are the even more distant impacts on human health and wellbeing.

Pathways from climate change to health and wellbeing can also be *"spatially distal".* For any country and its population, these distal pathways relate to those environmental impacts which are happening or predicted to happen elsewhere. These can involve quite dramatic environmental changes in countries and regions beyond their borders, yet little or no perceptible change to their own environment is experienced. Again, it is hard for the public and policymakers to appreciate the full impact of these events in the countries where they occur, still less how they might matter, for their own residents and their health and wellbeing. Perhaps the most obvious examples of spatially distal pathways arise when areas overseas are damaged by extreme weather events leading to flooding and drought, or from more long term environment degradation and conflicts over scarce resources. In such circumstances, populations are forced to move, often seeking shelter in more prosperous countries such as the UK (see Box 1 Climate Change and Migration).

Finally, pathways can be distal, essentially because they are complicated. Whether the climate-related environmental change occurs in one locality or concurrently across many regions, the pathway(s) which lead to the negative impacts on health and wellbeing usually involve an unfamiliar interplay of societal, economic and physical factors. This interplay can modify and often amplify risks. There are a growing number of examples of nutritional and health inequalities issues when climate change impacts global food security at the global scale (see Box 2 Climate Change and Food Security)

Although it certainly has temporal and spatial elements, the issue of climate change and pharmaceutical use offers another example of a climate-related health issue which is distal largely because it emerges from multiple complicated interactions between social and environmental systems. Pharmaceutical use worldwide is likely to increase in response to climate-related rises in the burden of disease and the emergence of conditions unfamiliar in counties like the UK. These climate factors in combination with an ageing demographic where there is a greater incidence of non-communicable and chronic disease" will almost certainly mean greater use of commonly prescribed medicines, but also of other seldom used medicines (Redshaw et al., 2013). The intentional or unintentional release of pharmaceuticals to the environment can be expected to impact on the structure and function of global and local ecosystems, undermining ecosystem services and, by extension, human health and wellbeing in many countries.

The long term resource implications for any country in responding to climate-related environmental change and its many implications is another climate change-related issue rendered distal because it is mired in complexity. For example, the decision as to whether to allow fracking in the UK which will provide short term increases in fossil fuel access, but which in turn will increase global CO_2 levels as well as causing

significant local social, health and ecosystem impacts (Kovats et al, 2014). Furthermore, current resource decisions will have major impacts on their equitable distribution and access in the future as climate change plays out over coming decades. This implies a future of difficult choices for those who shape policies and priorities within and between policy domains. Many such choices may have implications for health and health equity.

In consequence, any feeling of geographical or temporal separation from the effects of climate change including its health effects is likely to be illusory in a World connected through global economic, social, and ecological systems. The above examples, and many more, emphasise the potential damage to health and wellbeing from climate-relate changes impacting countries via a distal and not just proximal pathway. They make clear that for any community, region or nation to fully appreciate the potential health-related impacts of climate change, it is necessary to consider both the proximal and the distal pathways from anthropogenic drivers through ecosystem and environmental change to the consequences for human health and wellbeing. In other words, it is essential to conduct causal chain analyses of each stressor and their combinations, and ultimately to act with regards to both the proximal and the distal context. We consider the implications of this in greater detail below.

Integrated Impacts of Proximal and Distal stressors.

It is evident from this paper and the wider literature, that both the overt, short term, direct, climate-related (proximal) stressors, and the more remote, longer term, indirect (distal) stressors are acting together to generate threats to public health and wellbeing in any location.

Figure 1 illustrates how individuals and socio-economic groups in local environments are affected by a combination of these proximal and distal effects. There may be immediate effects, but also others which are subsequently translated to individuals and communities by economic, biogeochemical and resource flow mechanisms. These mechanisms linking vulnerabilities across space and time have been elaborated by Adger et al. (2009). The figure also recognises that the portrayal of a strict dichotomy between the distal and the proximal pathways from environmental change to human health and wellbeing, whilst convenient and often operationally useful, is inherently artificial. Macro and micro level processes continually interact and are tele-connected through systemic environmental processes, through the flows of material and mobility of populations around the world, and, most importantly, through market and economic linkages (Adger et al., 2009).

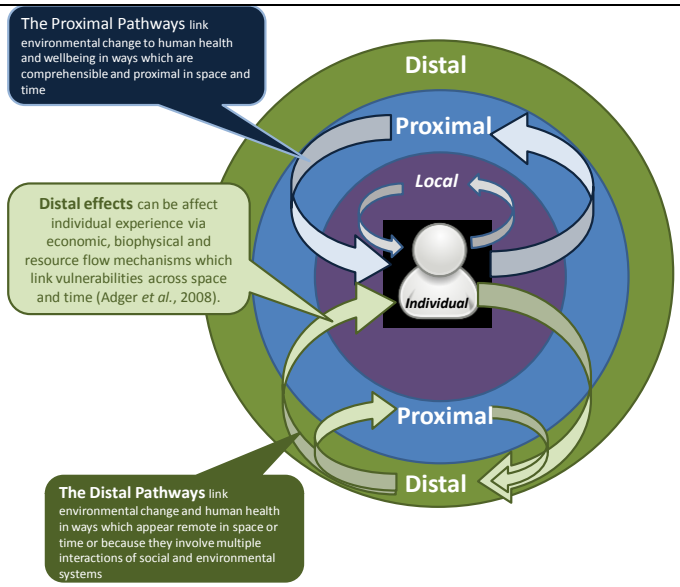

FIGURE 1: Pathways from Climate-Related Environmental Change to Human Health and Wellbeing in any Locality

Communication and Engagement.

Communicating both the immediate, proximal adverse health impacts of climate change together with the longer term, more diffuse effects, is a key challenge which has not yet been met (Lorenzoni et al, 2007)

We have argued above that unless communicated in more comprehensible and accessible ways, the distal pathways from climate change to health and wellbeing seem set to remain fractured and illogical to a significant and influential constituency, including policy makers. This means they will be under-accounted for in decision making. This is equally true of the pathways from other global environmental issues to health and wellbeing outcomes. The challenge of communicating and engaging the public, policymakers and politicians is not new in public health. Indeed, explaining human social complexity in relation to the determinants of health all but defined the public health challenge in the developed world for several decades (Lalonde, 1974; Dahlgren and Whitehead, 1992; Evans and Stoddart, 1994). However, the threat to health from global environmental change has multiplied this communication challenge by introducing the consideration of the health of ecosystems, not just human health, into the mix. The term "ecological public health" now describes a growing demand to modernise public health around ecological principles (Lang and Rayner , 2012; Rayner and Lang, 2012; Morris, 2010)

A particular challenge across the field of climate change is how to achieve recognition amongst the public and policymakers, that the choices they make drive climate-related environmental change wherever it occurs. This is the essential first link in every chain from the anthropogenic drivers of climate change to the immediate and distant health and wellbeing outcomes. However, if the necessary importance and priority are to be accorded to addressing this and indeed all global environmental issues, a much broader constituency must have a much clearer understanding of human reliance on natural ecosystems than currently appears to be the case. Such an understanding is central to making less opaque, particularly the distal pathways from climate-related environmental change to health and wellbeing.

Developing frameworks for fostering greater understanding

The use of simple conceptual models to think about and communicate human social complexity is well established in public health (Lalonde, 1974; Dahlgren and Whitehead, 1992; Evans and Stoddart, 1994). In earlier work (Morris et al, 2006; Reis et al, 2013), some of the authors have advocated the use of conceptual models to frame complex issues in the field of environmental health in a policy-relevant way. Morris et al. (2006) modified the established **D**rivers **P**ressures **S**tate, **E**xposure, **E**ffect, **A**ction or "DPSEEA" model (Corvalan et al., 1996; WHO. 2004) to better reflect social complexity in environmental health policy in Scotland (Scottish Government 2008; 2011). Such an approach is eminently suitable to exploring, engaging and communicating with policy makers and other stakeholders on the proximal health and wellbeing impacts of climate change in the UK.

More recently, Reis et al. (2013) built on the approach described above to develop an "ecosystems enriched" (or "eDPSEEA") model (Figure 2). Its purpose is to make explicit how environmental health must now consider not only the proximal environmental determinants of health and wellbeing, but also the impacts caused by anthropogenic damage to ecosystems. The eDPSEEA model incorporates the insights of the Millennium Ecosystems Assessment (MEA, 2005) by explicitly linking "ecosystem services" to human health and wellbeing within a notional chain of causation. It explicitly presents the health of both humans and of ecosystems as highly interconnected, and thus equally important to consider as outcomes.

Ecosystem Services are the benefits which humans derive from ecosystems. Early ecosystem service work focussed on measurable economics benefits (Costanza, 1997) and has evolved over time, informed in part by the 2005 MEA, to achieve a more inclusive and policy-relevant representation of the wider importance of ecosystem services. The MEA usefully identified four different types of ecosystem services: provisioning, regulatory, cultural and supporting. Importantly however, the MEA also projected how ecosystem services impact on human wellbeing, whether through the supply of material goods or through supporting social relations, security and freedom of choice. Since the publication of the MEA, the concept and structure of ecosystem services and their relationships with and relevance for humanity have been widely discussed. Fisher et al. (2009) distinguish between *intermediate* and *final* ecosystem services, highlighting that different services provide direct benefits, whereas others underpin ecosystem function. The UK-focused National Ecosystems Assessment (UK NEA 2011) also makes a very important contribution to the thinking in this area by offering a more forensic focus on the nature and importance of ecosystem services, based on the structure of the MEA. Current activities, for instance the global initiative *The Economics of Ecosystems and Biodiversity* (TEEB) (which focuses on the valuation ofecosystem services), or *Health & Ecosystems: Analysis of Linkages* (HEAL) apply the MEA ecosystem services categorisation, while the UK NEA explicitly acknowledges that ecosystem services, because they are defined in terms of their benefits to people are context dependent. This affects the valuation of ecosystem services in particular. This is because the same feature of ecosystem may be perceived as a service or benefit by one group of people, while not being valued other groups.

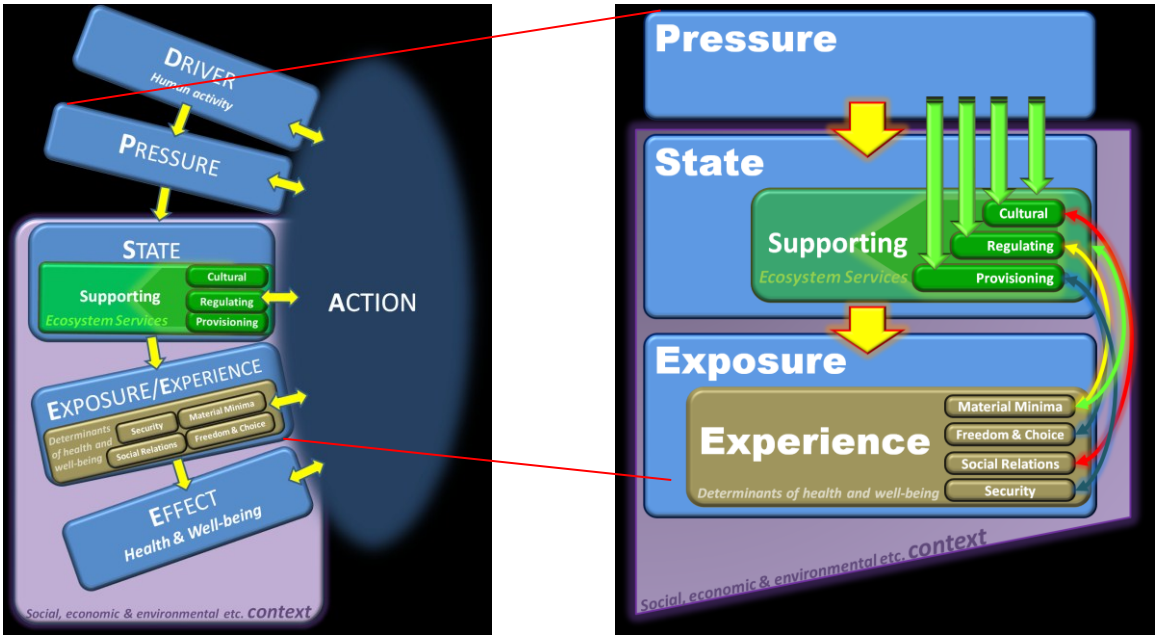

Figure 2: The Ecosystems Enriched eDPSEEA Model (Reis et al, 2013)

Figure 2 embeds the concept of ecosystem services and their relationships with both human health and the determinants of human health and well-being, more broadly. Accordingly, it can provide a framework for the operational exploration of challenges related to ecological public health, and specifically distal and proximal aspects of climate change. In the figure, the ecosystem services concept as portrayed by the MEA has been selected, but other representations are equally applicable - e.g. the representation by Fisher et al (2009) which distinguishes intermediate and final ecosystem services and their contributions to benefits to human health and well-being.

Both the process and the product of populating simple conceptual models can make more explicit some of the conceptually difficult distal pathways and also the proximal pathways through which climate change can impact on our health. In addition, this process can serve to promote a better understanding and engagement by stakeholders (including policy makers) around difficult issues such as climate change and its impacts on both human and ecosystem health. The eDPSEEA model is one of a range of potential conceptual models which could be used to support this endeavour (Reis et al. 2013).

When populating the eDPSEEA model (Figure 2) for any location, it is necessary to consider how (normally) anthropogenic **D**rivers result in **P**ressures impacting on the (proximal) environmental **S**tate, but also, potentially, on the ecosystems and the services they provide. Changes in the proximal environmental state can result in health-relevant **E**xposures, whilst changes to ecosystem services can affect wellbeing through undermining social relations, security, material minima and/or freedom of choice. In each case, the health Exposure/**E**xperience and the resultant **E**ffects are critically mediated, for individuals and communities, by social, economic, environmental, etc. contextual factors. Populating the contextual component of the model for a particular location (e.g. considering the local contexts which influence experience or outcome) promotes a richer discussion of how the impact of, in this case, climate change might be experienced differently in populations with differing

socio-demographic/socioeconomic profiles. Finally, to populate all the elements of the model, it is necessary to consider where **A**ctions may be targeted in order to secure beneficial outcomes for both ecosystem and human health and wellbeing.

We recognise that conceptual models are grossly simplified representations of real world situations. However, we argue that, properly developed or chosen, they can be tools with which to think in complex situations (McIntosh et al., 2010). Importantly too, they can be tools to communicate and engage, making explicit the missing links in chains of causation and comprehension for public and policy makers and they can foster engagement. This is particularly important especially for the more conceptually remote, distal pathways to health and wellbeing in the UK.

Conclusions

Systemic changes in global environmental systems, from the cycling of nutrients through to the global climate system represent a significant risk to health, wellbeing and health care in the future without major interventions for both mitigation of environmental drivers and adaptation to risks already in the pipeline. These risks affect the security and well-being of individuals and communities and have increasingly been recognised as affecting the ability of states to provide a safe, secure, healthy environment to allow their citizens to live productive healthy lives (see for example the Royal United Services Institute, 2014)

The potential for climate-related environmental change overseas to result in health and wellbeing impacts in a country like the UK is considerable. Complex global interconnectivities underpin the pathways which are spatially and temporally distal. Vulnerability to health effects in geographically distant places is translated to individuals and communities by economic, biogeochemical and resource flow mechanisms.

The public health community and decision makers must do more than simply elevate the profile of the environment amongst the social determinants of health. Future adaptation and mitigation policies should seek to ensure that benefits are available for all as current evidence suggests that they are spatially and socially differentiated, and their accessibility is dependent on a range of contextually specific socio-cultural factors (Thomas et al. 2014). We must develop a new environmental conceptualisation of public health which recognises vastly expanded temporal and spatial scales, and both distal and proximal causes. By extension, it must embrace the consequences of climate change and other environmental change (McMichael et al, 2006; Rayner and Lang, 2012; Reis et al, 2013, Dick et al., 2014). For example, the more frequent flooding events of recent years in the UK are now focussing attention on the climate-related environmental changes which present the more the proximal threats to our health and wellbeing and our ecosystems. However, for the public and policy makers to embrace the totality of health and wellbeing threats from climate change, it is necessary to take account of both the proximal and distal pathways.

The concept of ecosystem services and recent representations of their links to human health and wellbeing (MEA, 2005; Reis et al., 2013) can help to illustrate important links in many chains of causation. We also submit, that to fully understand

why climate-related change overseas really matters for health and wellbeing, an enhanced appreciation of the interconnectivities in global networks of governance, finance, business, communications, communities etc. is also essential (Foresight, 2011). As indicated above, global interconnectivities are many and complex. Over perhaps three decades, they have generated both benefits (e.g. through revolutions in knowledge, information and ideas around the world) and "dis-benefits" (e.g. through the unregulated flow of capital or vesting of power, often without democratic responsibility, with individual countries and transnational corporations) (Eakin and Lemos, 2006; Adger et al, 2009). Both the benefits and dis-benefits of globalisation are unevenly distributed between and within countries and regions, and are invariably socially patterned and stratified. Whist recognising an abundance of other examples, in this paper we have chosen migration and food security as important putative mechanisms through which health and wellbeing for UK residents can be affected by climate-related environmental change elsewhere (Boxes 1 and 2). Each portrays some of the complicated and complex nature of global interconnectivity.

The complexity of these distal issues demands that we develop new messages and especially new "tools to think with", to communicate, to engage stakeholders, and to configure a complex set of rapidly evolving qualitative and quantitative evidence. The conceptual model highlighted introduced in this paper may serve as one of these tools. The ecosystem services approach, used in the model, helps bring together environmental science and public health constituencies, and unites the processes of health impact and environmental impact assessment. The linking of ecosystem services to human health and wellbeing can be an important component in operationalising a new environmental conceptualisation of public health for the 21st century, Ecological Public Health.

As stated in the introduction, this paper was motivated by a desire to look beyond the proximal health impacts of climate change for the UK. In reality, the need for ways to find ways to explore and communicate the distal health impacts represents a shared imperative for every country and every community.

Box 1. Climate Change and Migration

Climate change will have an impact on where people live and on the decisions they make about moving from one location to another. Migration is a central element of economic and demographic change everywhere in the world. In effect, migration flows at the aggregate level are driven principally by differences in economic activity across space and time, though all individual decisions involve social, cultural and demographic dimensions. Individuals make rational choices: much migration to increase economic opportunities has, for example been shown, in aggregate, to improve overall well-being over the life course (Nowok et al., 2013).

Some elements of the relative attractiveness of different areas, and hence the demand for migration, are sensitive to weather and climate. Hence resource scarcity, the availability of ecosystem services, and issues of security and hazard, all factor in the relative attractiveness of places and decisions to move between them.

The scientific evidence for how important climate change may affect established migration patterns has been growing. The scientific and policy focus on migration has increased because of the perception of migration as a significant negative outcome of changing climate parameters, and also for its perceived challenges for public policy and well-being dimensions in receiving areas (Piguet et al., 2010; Foresight, 2011; Black et al., 2011; Geddes et al., 2012).

Research in economics, demography and political science has demonstrated that:

- most migration flows are of relatively short distance and within country borders;
- climate change-induced resource scarcity reduces the potential for capital accumulation in resource-sensitive economies and has a potential negative impact on the prospects for migration;
- displacement due to extreme events is likely to increase due to increased exposure;
- and rapid urbanization globally, partly amplified by migration, means that a growing number of populations are more exposed to weather and climate hazards.

Climate change is likely to affect different types of migration in different ways. Displacement of populations as a result of extreme events is usually temporary and undertaken involuntarily, but has major public health and policy consequences. Taking the example of the UK, flood events temporarily displace people from their homes, often for months after events (Milojovic et al., 2014). Most displacement is temporary but often amplifies migration trends. The well documented impacts of Hurricanes Katrina and Rita in Louisiana and New Orleans in 2005 show that temporary displacement of populations from flood impacts leads to highly differential permanent migration patterns, with only wealthier populations returning, thus changing the demographics of the whole region in the long term (Fussell et al., 2010).

A second interaction between migration and climate change is forced migration due to conflict. This type of migration is also typically involuntary and has implications in both conflict areas and population-receiving areas. However, direct link between climate risks and conflict risks is not well established, yet still an area of concern

(Adger et al., 2014; Gleditsch, 2012). In addition, conflict itself has significantly differential effects on the ability of populations to relocate from conflict zones (Raleigh, 2011) The IPCC Fifth Assessment emphasizes that climate change, if it is to affect conflict risk, does so through expanding poverty as a principal cause of insecurity and conflict. Hence, in theory there is a plausible route for increased risk in conflict-prone areas of the world over the incoming decades, in the absence of efforts for development and relief of the underlying causes of conflict in those regions (Adger et al., 2014).

The principal form of migration globally, however, continues to be the movement of populations to urban centres within their national borders. In terms of absolute numbers this trend is apparent and stark in Asia and Africa in particular (Parnell and Wallawege, 2011; Seto, 2011). Geographically, these migration trends are fuelling trends of population movement towards coasts and movement away from dry land and mountain environments (de Shernbinin et al., 2012). Hence on a global scale, the movement of migrant populations into cities and the potential for climate hazards in high density coastal mega-cities, air quality, and other affects, create significant public health challenges (Black et al., 2013), not least for the migrants themselves (McMichael et al., 2012).

The emerging scientific consensus on climate change and migration points to the health and wellbeing challenges of migration being highly significant, but that international migration flows are relatively minor compared to the issues of populations trapped in hazardous areas due to a lack of mobility and the issues of sustainable urbanization in places where migration is important.

Box 2. Climate Change and Food Security

There is a considerable and growing literature on the impacts of climate change on food production (Challinor et al 2014, IPCC WG2). Relative to an unchanging climate and all other things being equal, yields are likely to fall on average worldwide (Nelson, Valin et al., 2013; Challinor et al., 2014; IPCC WG2). These changes are spatially sensitive, with yield decreases likely to be greater in the hotter parts of the world (Wheeler and von Braun, 2013). However, there is considerable scope for the food and trade-system to adapt to climate change (Nelson, Valin et al., 2013). This might be achieved via changes in the area of production and through impacts on trade and prices. However, given the complexity of the system, it is not clear how the multiple potential drivers of food availability and price will interact around issues such as: food for feed (Wheeler and Reynolds, 2013); biofuels (Taheripour, Hertel et al., 2013); carbon pricing (Smith, Haberl et al., 2013); water availability (Immerzeel, van Beek et al., 2010); competition for land and other resources (Smith, Gregory et al., 2010); and the need for agriculture to be sustainable (Tscharntke, Clough et al., 2012). Of particular concern is that increasing weather variability may lead to supply-demand imbalances (Challinor et al 2014, IPCC WG II) that create significant volatility in food prices, impacting on the food security of the poorest peoples around the world.

Needless to say, variation in prices (driven by weather-related impacts accentuating demand/supply imbalances, perhaps amplified by financial instruments (Spratt 2013)) has its greatest impact on the poorest. Analysis of purchases following the 2007/8 food price spike show a complex pattern of responses to food price increases. As prices increased, households in, for example, Britain did indeed buy 4.2% less (DEFRA, 2012). They also traded down to save money, by buying cheaper alternatives. Despite this, they spent 12% more in 2011 than 2007. The worst impact was on the poorest 10%: when you have already traded down to save money, there is little scope for doing anything but buying less or paying more (or both). The poorest spent 17% more in 2011 compared to 2007, so their relative food bill increased by 40% more than the UK average. The growth of food handouts, as exemplified by the Trussell Trust's figures (about 915,000 people received emergency food aid in 2013-14), showed that access to food, and its price relative to income are a real issue in the UK. In addition, there is a significant increase in obesogenic diets as people get poorer. Thus, weather impacts from climate change are likely to impact the nutritional and future health status, especially of the 11.4m people in relative poverty in the UK (after housing costs deducted) in 2011, a figure projected to rise to 14.3m by 2020 (Browne, Hood et al., 2013).

Selecting another food-related example, North West Europe may expect relatively fewer impacts of climate change than other regions. It may therefore increase its relative competitive advantage in food production relative to major calorie producing regions such as South America, the mid-West, the Indo-Ganges and SE Asia, and China. In turn, this may incentivise specialisation in high-volume products for exports. However, a consequent reduction in the diversity of local produce could create greater reliance on imports and reduced resilience in the event of a shock. In addition, the impacts of growing more food for export may, in turn, lead to significant changes in the environment, affecting ecosystem services that impact upon health and well-being (e.g. impacts on water, the amenity and cultural values of the landscape, etc).

The growth of demand for food, driven by rising population size and wealth, and the need to undertake this sustainably, have been widely discussed in a variety of reports (e.g. those of the IPCC and UK Foresight). In a considerable amount of the food security literature, demand is regarded as a "given," driven by relationships with increasing wealth (Valin, Sands et al., 2013), towards which production-side interventions need to be directed. However, as the world changes, as do our attitudes to, and knowledge of, the relationship between food and health, it is not clear to what extent demand may change, or demand will interact with changing food and its availability and price (Nelson, 2013; Valin et al., 2014) to drive changes in global agricultural production.

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