been made. While such flexibility helped secure participation from all countries, the lack of detailed emissions information is problematic for understanding the impact of INDCs towards meeting global climate goals. Without this information, determining overlap between national, non-state, and subnational actions could become more difficult. Vague metrics may also provide cover for low ambition. Early analysis of the INDCs shows that current pledges are only half of what is needed to limit global temperature rise to 2 °C (ref. 16).

Leave room for innovation. At the same time, the criteria for inclusion should not be too strict. Some proponents argue for the integration of subnational and non-state actions into the UNFCCC. Others caution that this integration would prevent innovation and risk-taking among new actors. A major contributor to the Summit's success in engaging a diversity of participants was the flexibility afforded to the content of commitments. The Summit's openness brought in businesses and other actors who would have been otherwise hesitant to commit at such a high-level forum. Meetings like this could play a key role in fostering new thinking and ideas for addressing climate change, as they have lower costs of failure than a formal process such as the UNFCCC. Any framework that includes non-state and subnational participants must achieve a delicate balance between establishing a bar that boosts ambition but is not so high as to deter critical actors from joining.

States are no longer the only actors tackling climate change. The Summit represents a new mode of elevating the groundswell of non-state and subnational action into official political channels. This integration is crucial to making a fragmented climate governance system effective. Tenuous financing and uncertain implementation, however, mean that the Summit's commitments have a high risk of failure, potentially damaging the credibility of future non-state and subnational efforts. To avoid such a pessimistic conclusion, new methods of pledging and accountability, as well as innovative modes of governance, are needed to seriously engage new actors. ❐

Angel Hsu[1], Andrew S. Moffat[2], Amy J. Weinfurter[2] and Jason D. Schwartz[2] are at [1]Yale School of Forestry and Environmental Studies, Yale University, 195 Prospect Street, New Haven, Connecticut 06511, USA. [2]Yale Center for Environmental Law & Policy, Yale University, 195 Prospect Street, New Haven, Connecticut 06511, USA.

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Additional information

Supplementary information is available in the online version of the paper.

COMMENTARY:

Socio-economic data for global environmental change research

Ilona M. Otto, Anne Biewald, Dim Coumou, Georg Feulner, Claudia Köhler, Thomas Nocke, Anders Blok, Albert Gröber, Sabine Selchow, David Tyfield, Ingrid Volkmer, Hans Joachim Schellnhuber and Ulrich Beck

Subnational socio-economic datasets are required if we are to assess the impacts of global environmental changes and to improve adaptation responses. Institutional and community efforts should concentrate on standardization of data collection methodologies, free public access, and geo-referencing.

There is a scalar mismatch between social scientists focusing on the nation-state and climate scientists operating at the global level[1]. From the natural science perspective, climate change is an egalitarian and cross-border phenomenon, and research results are routinely analysed beyond national borders. The social sciences, however, have evolved historically within nation-states, and the production of data is mostly framed according to nation-state boundaries; this includes international comparisons. Overcoming this 'methodological nationalism' requires both cosmopolitan and subnational data[2].

Cosmopolitan data are needed to grasp the interconnectivity and interdependence of global, national and local issues. To obtain data at a subnational scale, for example on water use in different sectors

and water prices, scientists usually have to visit the region and literally photocopy the information from local administrative organizations[3]. Such a process is time-consuming; also, data pooled from different countries and administrative units often use different methodologies and definitions and therefore must be standardized before use[4]. In contrast, the impacts of global environmental changes occur within climatological and geo-ecological units rather than administrative boundaries. Thus, the social impacts of global environmental changes may not be detectable by studying national averages.

In an illustration of this problem, we compare national and spatially explicit hunger indicators, and show that hunger is not equally distributed within national borders but is spatially concentrated in certain areas (Fig. 1). In many such areas, such as the Chad Lake Basin on the borders of Niger, Nigeria, Chad and Cameroon, for example, food production is threatened by decreasing and uncertain water availability[5]. The local effect of droughts on hunger occurrence or any other climate-induced socio-economic trend visible at the river-basin level is likely to disappear in averages at national level. At least 261 of the world's major rivers are shared, with 176 flowing through two countries, 48 through three countries, and 37 through four or more countries[6]. Although there are several programmes designed to exchange data within river basins, these primarily focus on hydrological data rather than socio-economic data[7].

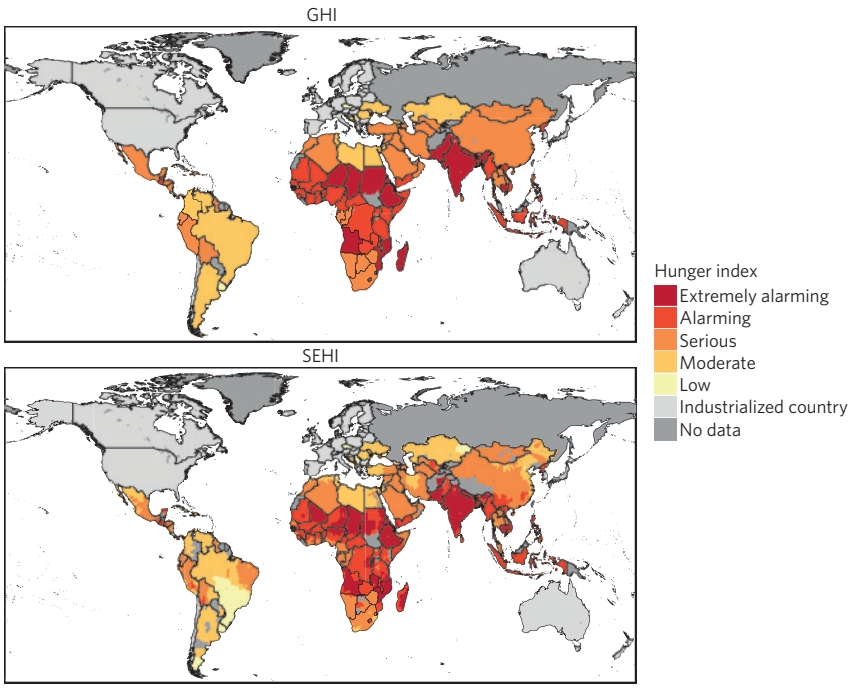

Figure 1 | A comparison of the Global Hunger Index (GHI) and the Spatially Explicit Hunger Index (SEHI). The global hunger index (GHI) provided by the International Food Policy Research Institute (IFPRI)[6] combines three equally weighted indicators: a national average of the proportion of people that are undernourished, and two subnational indicators — the percentage of underweight children younger than five, and the mortality rate of children younger than five[7,8]. In our spatially explicit hunger index (SEHI), we replace the national average of the proportion of people that are undernourished used by IFPRI by a subnational (0.5°) indicator, provided by the Food and Agriculture Organization[9], on the prevalence of stunting among children under five. The SEHI reveals that patterns of hunger are not bounded by national borders. The data are assembled for varying years from 2000 to 2011.

Stationarity in social sciences

To assess climate impacts and to develop strategies for adaptation and other global challenges, a different approach to data gathering and management is needed. Currently, most resources, externalities of economic activities and populations are not restricted to national borders; they become increasingly interconnected, and large and rapid shifts in these factors may occur. As an example, annually more people are reported to be displaced by natural disasters than by conflicts. By 2050, between 25 million and one billion people are projected to be forced to migrate because of climate change and other environmental factors[8]. Such estimates are mostly based on the physical occurrence of natural disasters, on which data exist. But there is no systematic database on current environmentally induced cross-border migration, nor on the number of people displaced by slowly occurring environmental changes[8], and no data on transit migration. The stationarity of data gathering has to be overcome[9,10] in social sciences, and the changes in our societies need to be reflected by use of new methods and new categories in socio-economic statistics.

In natural climate science, this process was initiated with the establishment of the International Meteorological Organization in the 1870s, succeeded by the World Meteorological Organization in 1951. These organizations instigated the consolidation and exchange of national weather data. It took many decades, however, to overcome national (military and commercial) interests and the inertia of installed infrastructure, and to standardize meteorological data on a global scale[11]. In fact, it is only since the start of the satellite age in the 1960s that an infrastructure for generating global weather and climate data has emerged.Today, climate scientists have access to snapshots of the state of the atmosphere every 6 hours, real-time information on the extent of Arctic sea-ice, continuously updated global data, and much more. They can also make use of records of temperature and precipitation that stretch as far back as the late nineteenth century, with near-global coverage. These datasets have proved invaluable for our understanding of climate change and of the role of natural variability and anthropogenic forcing, including attribution of extreme weather events[12,13]. Furthermore, they have triggered global 'system thinking', both in and outside the scientific community, highlighting the limits to our planetary resources.

A new paradigm in data gathering

Data and information to aid in the understanding of complex problems are key to the successful governance of common pool resources, including global commons[14]. To address urgent questions related to the world's foremost challenges, the social sciences and institutions gathering data will have to react and adapt more quickly to global challenges. Given current information and communication technologies, including the Internet, crowd sourcing and geographical information systems, and the fact that most national datasets are already digitized, this should be technically possible in a relatively modest time span. Available global geo-referenced databases, for example on demographic and economic indicators,

Table 1 | Examples of existing global data sources relevant for researching social impacts of global environmental changes.

Indicator	Source	Lowest resolution level	Available years of observations
General demography			
Population density	Center for International Earth Science Information Network (CIESIN)	2.5′ × 2.5′ grid	2005, 2010, 2015
Population number, mortality, fertility	UN Population Division	National	1949–2012
Life expectancy	WHO, OECD, World Bank	National	1960–2012
Infant mortality rate	CIESIN	Subnational, 0.25° × 0.25° grid	2000
Education			
Literacy, school enrolment (by gender and age)	UN Gender Statistics	National	1990–2010, many missing observations
School enrolment	World Bank	National	1970–2012, many missing observations
Economic			
GDP per capita	Geographically Based Economic Database (G-Econ)	Subnational, 1° × 1° grid	2005
Food price	Food and Agriculture Organization	For several countries subnational at the province level, otherwise national	Monthly 2000 to present
Migration			
Persons of concern for UNHRC[a]	United Nations Human Rights Council (UNHRC)	Subnational at the province level	2000–2012, many missing observations
Asylum-seekers	UNHRC	National	2000–2012
International migrant stock	UN Population Division	National	1990–2010
Poverty			
Poverty rates in different age groups	OECD	National	1983–2011, many missing observations
Percentage of the population living on less than US$2.00 a day	WB	National	1980–2012, many missing observations
Child malnutrition	CIESIN	2.5′ × 2.5′ grid	2005
Behaviour and perceptions			
Perceived seriousness of global warming	World Value Survey	National	2009
Ecological footprint	Global Footprint Network	National	1961–2007

[a]Persons of concern for UNHRC including refugees, asylum-seekers, returned refugees, internally displaced persons (IDP), returned IDPs, stateless persons and others.

show that such efforts are possible (see Table 1). But these databases are only available for restricted time periods, and the highest spatial resolution available is usually the national level, often with many missing countries or ambiguous values. For example, the OECD and World Bank report different life expectancy values for the same countries over the same time period.

Homogenization of data collection methodologies, free public access to data at a subnational scale, together with geo-referencing of socio-economic data should be given the highest priority. Existing international organizations dealing with global environmental and social challenges could take a lead in this process.

Currently most international socio-economic data is collected by the United Nations Statistics Division (UNSD), to which data are supplied by National Statistics Offices through UNSD questionnaires and censuses[15]. The United Nations provides mandates to other international organizations such as the World Bank or the World Health Organization (WHO) to deal with specific data challenges such as on poverty or health. One possible move towards improving the subnational data accessibility would be to ask national statistical offices to add subnational entries in the UNSD questionnaires. The subnational level agreed on would have to be large enough to protect the anonymity of respondents, yet explicit enough to enable the disaggregation of national data. For example, the spatial resolution of 0.5° that corresponds to an area of 50 km^2 at the Equator (and is roughly the area administered by local governments in many modern nations) could be a suitable solution.

A short unpublished survey that we carried out among employees in statistic divisions of international organizations highlighted that implementing the above changes would require more data scientists and different data management strategies. It was also pointed out that providing homogenized subnational-level data, especially in low-income countries, would require substantial improvements to the local data collection infrastructure. These are important challenges that would have to be overcome by international agreements and the reallocation of funding necessary for improving data infrastructure and management.

In addition, bottom-up and crowd data pooling initiatives should be encouraged. There are numerous regional case studies and research involving household surveys being carried out all over the world, and good scientific practice codes could encourage standardization of data gathering and data accessibility. Improved information exchange and information access can help to generate a better understanding and awareness of the interconnectedness between global environmental changes and social impacts, and through this, increased adaptation capacity at the global and local levels. ❐

Ilona M. Otto[1,2], Anne Biewald[1], Dim Coumou[1], Georg Feulner[1], Claudia Köhler[1], Thomas Nocke[1], Anders Blok[3], Albert Gröber[4], Sabine Selchow[4,5], David Tyfield[4,6], Ingrid Volkmer[7], Hans Joachim Schellnhuber[1,8] and Ulrich Beck[4] are at: [1]Potsdam Institute for Climate Impact Research, Telegraphenberg A31, Potsdam, 14473, Germany; [2]Zhejiang University, School of Public Affairs, Yuhangtang Road 866, Hangzhou 310,058, China; [3]University of Copenhagen, Department of Sociology, Øster Farimagsgade 5, Postboks 2099, Copenhagen 1014, Denmark; [4]Ludwig-Maximilians-Universität, Institute for Cosmopolitan Studies, Konradstrasse 6/203, Munich 80801, Germany; [5]London School of Economics and Political Science, Department of International Development, Houghton Street, London WC2A 2AE, UK; [6]Lancaster University, Lancaster Environment Centre, Bailrigg, Lancaster, LA1 4YT, UK; [7]University of Melbourne, School of Culture and Communication, Victoria 3,010, Australia; [8]Santa Fe Institute, Santa Fe, 1399 Hyde Park Road, Santa Fe, New Mexico 87501, USA.*
**e-mail: ilona.otto@pik-potsdam.de*

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We dedicate this paper to the memory of Professor Ulrich Beck (1944–2015), the pioneer of cosmopolitan social science in a world of global climate risks.

COMMENTARY:

Local science and media engagement on climate change

Candice Howarth and Richard Black

Climate scientists can do a better job of communicating their work to local communities and reignite interest in the issue. Local media outlets provide a unique opportunity to build a platform for scientists to tell their stories and engage in a dialogue with people currently outside the 'climate bubble'.

Surveys, including those carried out regularly by the UK's Department of Energy and Climate Change (DECC), show that a majority of the British public accept that climate change is happening, are concerned about it, and favour action to reduce greenhouse-gas emissions[1]. However, public acceptance of climate change has reduced over the past five years. This may be connected with a lack of appreciation of the scientific consensus, which by several measures exceeds 90% (ref. 2). In 2014, a ComRes survey of 2,000 members of the British public, commissioned by the Energy and Climate Intelligence Unit, found that only 11% of respondents appreciated the extent of the scientific consensus on climate change; nearly half (47%) did not think there was a consensus at all[3]. Although the DECC (and other) surveys regularly show high levels of support for renewable energy technologies such as wind and solar power, the ComRes survey found that only 5% of the population knows that support is this high; more than half of the population (63%) thinks that the public is opposed.

The methods by which people receive, interpret and understand information on climate change is important as it affects their resulting actions[4]. The importance and relevance of place attachments in understanding human responses to climate change is known[5], and by incorporating elements of 'daily life' (which by definition is lived at a local level), media portrayals can enable climate science and governance to be interpreted through a local, everyday lens[6].

Yet the communication of climate change historically has been generic, untailored and untargeted. A transition to a situation in which public engagement on climate change goes beyond information provision and instead adopts a more active approach underpinned by constructive dialogue between scientists and the media could therefore be fruitful. Increasing engagement on the local dimensions of climate change could facilitate this and enable a stronger connection to the issue.

The 2013–2014 winter saw a sequence of serious flooding events across much of the UK. Both a survey commissioned by Avaaz at the height of the floods[7] and the ComRes survey six months later, suggested that these events affected public opinion on climate change. In the first, nearly half of respondents said they believed the floods were linked to climate change. In the second, half said that the floods had increased their belief in climate change, and a quarter said it increased their belief in human agency. The flooding was a major story on national and regional media for weeks and the subject of intense political discourse, and these studies could not untangle the question of whether local or national factors were involved in people making the weather-climate link. However, a study on the 2012 floods in Wales[8] indicated that local experience is important; people directly exposed to flooding were more likely to accept evidence for climate change, and to believe that their own actions could have an impact by reducing carbon emissions.