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Socio-economic data for global environmental change research

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Sub-national socio-economic datasets are required to assess the impacts of global environmental changes and to improve adaptation responses. Institutional and community efforts should concentrate on homogenization 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 sub-national data[2].

Cosmopolitan data are needed to grasp the interconnectivity and interdependence of global, national, and local issues. To obtain data at a sub-national scale, e.g. on water use in different sectors and water prices, scientists usually have to visit the region to, literally, photocopy it from local administrative organizations[3]. Such a process is time consuming, but also data pooled from different countries and administrative units often has to be homogenized due to the use of different methodologies and definitions[4]. In contrast, the impacts of global environmental changes occur within climatological and geo-ecological units rather than administrative boundaries. Thus by studying national averages, the social impacts of global environmental changes may not be detectable.

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 (Figure 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 socioeconomic 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 programs designed to exchange data within river basins, these primarily focus on hydrologic data rather then socio-economic data[7].

Stationarity in social sciences

To assess climate impacts and to develop strategies for adaptation and other global challenges, a different approach in data gathering and management is needed. Currently, most resources, externalities, and population 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 due to climate change and other environmental factors[8]. Such estimates are mostly based on the physical occurrence of natural disasters, on which data exist. However, there is no systematic database on 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 have 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, that was 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, the inertia of installed infrastructure, and to standardize and homogenize 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-gridded data stretching back to the late 19th century, and much more. These datasets have proved invaluable for our understanding of climate change, and 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 planetary limits.

Towards a new paradigm in socio-economic data gathering

Data and information to facilitate 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 geographic 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, show that such efforts are possible (see Table 1).

However, 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 of international socio-economic data is collected by the United Nations Statistics Division (UNSD), to which data is 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 to deal with specific data challenges such as on poverty or health. One possibility towards improving the sub-national data accessibility would be to ask National Statistical Offices to add sub-national entries in the UNSD questionnaires. The sub-national level agreed on would have to be large enough to protect the anonymity of respondents and 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 roughly the area administered by local governments in many modern nations could be a suitable solution.

A short 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 sub-national 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 also 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 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.

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Other information: We dedicate this paper to the memory of Professor Ulrich Beck (1944 – 2015).

Figure 1: 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 sub-national indicators: the percentage of underweight children younger than five and the mortality rate of children younger than five[7,8]. In the Spatially Explicit Hunger Index (SEHI) we replace the national average of the proportion of people that are undernourished used by IFPRI by a sub-national (0.5°) indicator on the prevalence of stunting among children under five provided by Food and Agriculture Organization[9]. The data are assembled for varying years from 2000-2011.

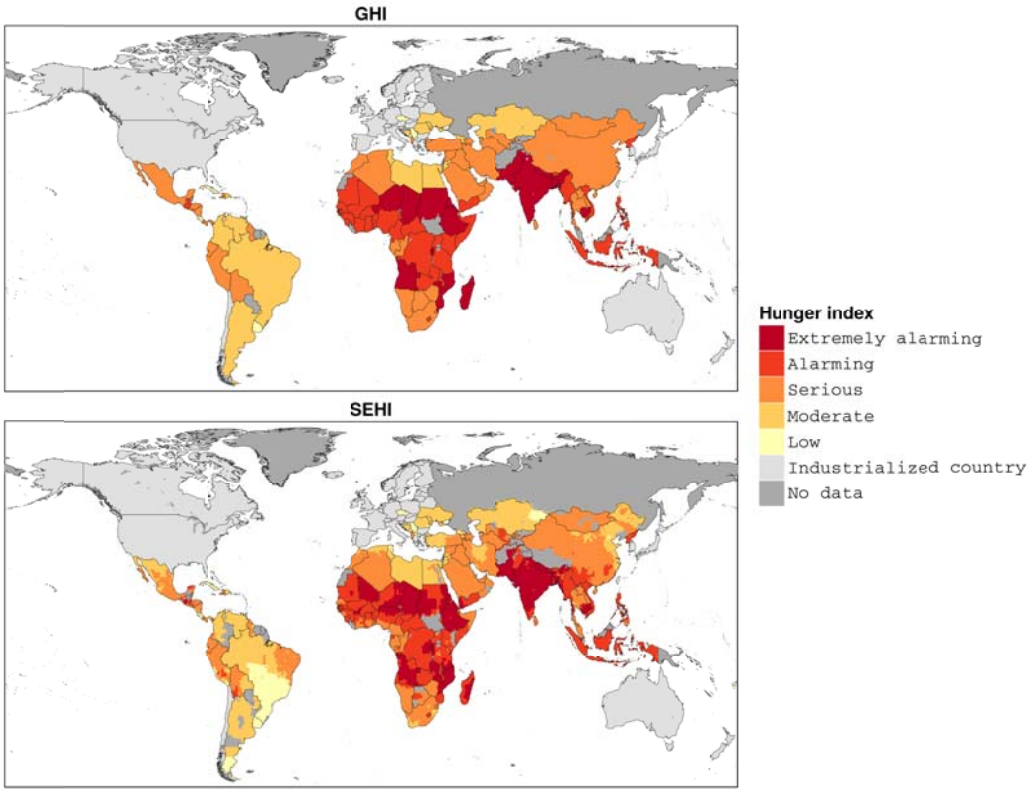

Table 1: Examples of existing global data sources relevant for researching social impacts of global environmental changes

Sector	Indicator	Source	Lowest resolution level	Available years of observations
General demography	Population density	Center for International Earth Science Information Network -(CIESIN)	2.5'x2.5'grid	2005, 2010, 2015
	Population number, mortality, fertility	UN Population Division	National	1949-2012
	Life expectancy	WHO, OECD, WB	National	1960-2012
	Infant mortality rate	CESIN	Sub-national, 0.25˚x0.25˚ grid	2000
Education	Literacy, school enrolment (by gender and age)	UN Gender Statistics	National	1990-2010, many missing observations
	School enrolment	WB	National	1970-2012, many missing observations
Economic	GDP per capita	Geographically Based Economic Database (G-econ)	Sub-national, 1˚x1˚ grid	2005
	Food price	FAO	For several countries sub-national at the province level, otherwise national	Monthly 2000-present
Migration	Persons of concern for UNHRC*	United Nations Human Right Council (UNHRC)	Sub-national-province	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
	Poverty headcount ratio at $2 per day	WB	National	1980-2012, many missing observations
	Child malnutrition	CESIN	2.5'x2.5'grid	2005
Behavior and perceptions	Perceived seriousness of global warming	World Value Survey	National	2009
	Ecological footprint	Global Footprint Network	National	1961-2007