Will climate change shift demography's 'normal science'?

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Like any science, the study of population has been guided by *normal science*, as defined within the discipline. As Thomas Kuhn (1962) famously postulated in *The Structure of Scientific Revolutions*, researchers follow *normal science* until a crisis level of unexplainable anomalies is reached—i.e. anomalies that push the limits of current paradigms.

The paradigms guiding population science may, in fact, be increasingly outdated in their exclusion of environmental factors. Yet rather than debating 'narrow-mindedness', we devote this brief essay to a consideration of the conditions required for demographers to make worthwhile contributions to current discussions of climate change.

A valuable example of a recent paradigm shift within population studies is the trend toward studying biological and genetic determinants of population processes. More than 15 years ago, a vigorous debate took place over whether biological/genetic data could provide new opportunities for understanding population processes, whether the relevant theories and data existed, and what forms of training and amounts of funding would be required to support these new research approaches (e.g. Finch et al. 2001). Since then, considerable time and energy have been devoted to training population scientists in these new areas, and to pursuing the opportunities presented by this new line of research. Time will tell whether these efforts have an important impact.

This case provides a useful parallel in answering the question regarding the involvement of population scientists in climate change research. To be sure, demographers have long danced around the more general issue of connections between population development and the environment. In 1998, PAA President Anne Pebley reviewed this tendency and put forward arguments to explain why demographers have avoided directly addressing environmental concerns. In the end,

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Pebley argued that "there are important reasons for demographers to become more involved in research on environmental issues" (1998: 385). As we move further into an era of 'major and still growing impacts of human activities' on ecological systems—a geological epoch informally described as the Anthropocene (Crutzen 2006: 16)—the direct engagement of demographers with environmental issues becomes all the more imperative.

Below we discuss why we believe the time is ripe for population scientists to become more involved in research on climate change. Our argument comprises four key points.

First, while environmental aspects of classic demographic theories have not been emphasized in population research, there is evidence of recent change

Consider Caldwell's classic 'wealth flows' theory of fertility decline and its central theme of children's contributions to household economies (Caldwell 1976). The role of children's labor within agricultural households was key to Caldwell's argument, although most subsequent research on fertility even in resource-dependent settings ignored the role of environmental reliance. Recent research in rural Kenya added to our understanding of the connection between fertility and the environment by showing that land shortages appear to have played a role in the nation's dramatic fertility decline (Shreffler and Dodoo 2009).

A similar critique could be made of migration research, which has until recently largely ignored environmental determinants. The failure to include these determinants is surprising given that contextual factors are critical to many classic migration theories such as push-pull, Wolpert's stress threshold model (1966), and Speare's residential satisfaction framework as related to migration decision-making (1974). Spurred by climate change concerns, migration scholars have, however, recently made substantial progress in bringing environmental factors into migration research, with some generalizable findings emerging, including evidence on the distinctions between the migratory impacts of short-term environmental events and long-term challenges such as drought. In addition, a recent conceptual framework by Black and colleagues (2011) presents a nice overview of how these short- and long-term environmental pressures interact with macro forces (e.g. political, economic, social), and in turn interact with personal and household characteristics to shape migration decision-making.

Second, the data and the methodological challenges that have discouraged demographers from integrating environmental considerations are being addressed

The integration of environmental issues within population research requires us to know not just who people are, but where they are. Yet much of the readily available microdata often used by demographers have not had geographic identifiers that allow for the attachment of data reflecting local environmental conditions and changes in those conditions. As Barbara Entwisle argued in her PAA Presidential Address on linking neighborhoods and health, this kind of research requires 'putting people into place' (2007: 687).

Some researchers have identified opportunities within other data sources to examine population-environment connections. One example is Gray and Mueller's (2012) use of data from the Chronic Poverty and Long Term Impact Study collected by the International Food Policy Research Institute to examine the impacts of flooding on migration in rural Bangladesh. Another example is the use by Hunter, Twine, and colleagues of geographic information within the Agincourt Health and Demographic Surveillance Site data to study migration as related to proximate natural resources in rural South Africa (Hunter et al. 2012; see review by Fussell et al. 2014). These types of analyses could be used to examine demographic scenarios under different climate futures.

In addition, methodological advancements also allow for the integration of contextual factors within micro-level analyses. For example, multi-level models, spatial analytical techniques, and agent-based approaches are increasingly being applied to gain a better understanding of population-environment connections.

Third, there are demographers who are emphasizing climate change

There are examples of important inroads made by demographers in studying both the influences of climate on population processes and the role of population in climate change. These pathways lead to other logical entry points for combining population and climate change concerns.

A particularly prominent example is the work of O'Neill and colleagues in bringing demographic nuances, such as issues of aging and urbanization, into models of economic production and consumption, based on the premise that these factors will ultimately drive climate changing carbon emissions (e.g. O'Neill et al. 2010). This type of demographic research can directly inform climate science by improving our understanding of the demographic trends that underlie human-induced climate change. This line of inquiry represents a much-advanced version of the classic IPAT model of Impact = Population $*$ Affluence $*$ Technology (Ehrlich and Holdren 1971).

Yet another example is the effort by Balk, Montgomery, and colleagues (2010) to improve the spatial dimensions of population projections, which can, for example, help us identify population densities in low-lying coastal regions of Bangladesh. Such work is critical to the formulation of policies and programs designed to reduce vulnerability to climate change, particularly sea level rise.

At the household level, research on migration from rural Mexico has recently integrated climate measures to help explain future migratory potentials under shifting environmental futures (e.g. Nawrotzki, Riosmena and Hunter 2013). Insights from this work can improve targeted policies and programs aimed at enhancing household resilience.

Fourth, there are opportunities for including climate change issues in population research

Demographers might be encouraged to consider the ways in which climate affects their topics of study, including fertility and migration. Climate change may be

of particular relevance for populations with high levels of dependence on local environments. Demographers can also contribute useful expertise to the study of climate change vulnerability and adaptation, helping to improve our understanding of who is in harm's way, and what types of responses may be anticipated or desired. Demographers may also be encouraged to apply their population expertise more directly to the study of climate drivers, along the lines of the work of O'Neill.

Any of these entry points into population-climate research can benefit from the incredible array of newly available data that allow us to link population and environmental processes in ways that were not previously possible. For example, demographers could draw upon microdata from TerraPopulus, an initiative to link international census data with information on land and climate data (www.TerraPop.org). A rapidly expanding pool of macro- and microdata resources are also available through the Center for International Earth Science Information Network (CIESIN), a center within the Earth Institute at Columbia University (http://www.ciesin.org/). Finally, as climate scientists continue to recognize the critical nature of demographics, opportunities are growing for important collaborations between population and climate researchers. Demographic scholars already engaged in research on projections and projection methodology would be likely be candidates for collaborations with climate scientists involved in projecting future emissions.

Science is a social product—and the social landscape is changing

The pursuit of knowledge is shaped by societal values, norms, and interests (Merton 1973). Across the world, values, norms, and interests are shifting as climate scientists continue to generate evidence of human-induced change and public concerns about climate change continue to grow. Policy-makers are responding: consider the recent Dutch court ruling mandating that the government increase efforts to combat climate change. At a more fundamental level, the socio-political landscape in which we conduct our research is changing, and the new emphasis on understanding the social, economic, and political dimensions of climate change calls for new ways of doing demography. Shifting temperatures and rainfall will alter migration probabilities, while natural disasters and sea level rise will affect patterns of population health.

Even so, until the case is made that climate change is important to our science and that we have or can develop adequate tools for taking climate change into account, demographers, like other social scientists, will continue on their usual research paths. The many new opportunities to take advantage of geographically referenced microdata should help to bring climate issues into demographic research. But who is in the best position to make the case for the inclusion of climate factors? It is likely to be those demographers who have already engaged in climate research, climate scientists who see the need for demographic nuance, and, crucially, funding agencies willing to invest in population-climate scholarship. We must make the case for the integration of climate into population research and of population into climate

science so that both disciplines can move forward from their current normal science stances. It is our hope that this debate contributes to establishing that case.

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