At this point, the researchers ran their model into the future on the basis of climate scenarios (above-average, normal or below-average rainfall in the different regions of Burkina Faso) and demographic scenarios of population growth. The simulations illustrate how drier conditions substantially enhance migration only because of a complex chain of causalities between rainfall, population growth and social networks. Taken in isolation, the impact of the climate factors remains non-significant.

The processes that lead an individual to migrate in response to climate signals are much more complex than the segregation processes studied by Shelling and, arguably, also than many other phenomena addressed in ABM[10] studies. Given such complexity, the socio-demographic processes as well as the rules of behaviours taken into account in Kniveton and colleagues' model remain simplistic. At this stage, additional research is needed to confirm the promising perspectives opened up by ABM. A much deeper theoretical understanding of the migration decision-making processes at stake and more extensive household surveys are needed. This should help in drawing conclusions on the existence of behaviours regular enough to allow mathematical formalization. Nevertheless, Kniveton and colleagues' findings[2] represent a breakthrough in the literature linking climate change and human migration. As noted by the researchers: "The development of an agent-based model investigating the impact of rainfall variability on migration serves as a heuristic device to understand the characteristics of aggregate migration behaviour in response to climate change and variability." Population displacements linked to climate change represent a major challenge for the future. A better understanding of such processes is a central task for migration studies. Kniveton *et al.* show that ABM can significantly improve this understanding. The study confirms the role of ABM as a methodological toolkit and opens up a fascinating research programme. ❐

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MIGRATION

Flooding and the scale of migration

Immobility rather than mobility should be the focus of concern for policymakers worried about the impact of climate-related natural hazards on the livelihoods of rural populations.

Allan M. Findlay

The conventional wisdom that climate change will stimulate permanent mass migration needs to be re-examined. Experts[1,2] have suggested that very significant population movements, involving hundreds of millions of people, will take place over the next 50 years as a result of the impacts of climate change. This position has been increasingly questioned by population researchers with expertise in migration[3]. Do climate-related natural disasters result in long-term and long-distance population displacement? This is a key question that two geographers, Clark Gray and Valerie Mueller, have tackled in a recent paper in *Proceedings of the National Academy of Sciences*[4]. They have found that flooding has only a modest long-term impact on migration; crop failures that are not related to flooding have a much greater effect in stimulating population mobility.

Environmental scientists usually assess the mobility impact of climate change by calculating population numbers living in regions at risk of being impacted by natural hazards, on the assumption that population migration will follow a hazard event. Gray and Mueller engage with the topic differently by examining population mobility (and immobility) in rural Bangladesh. They ask whether flooding is significant in stimulating movement relative to other factors such as crop failure. This approach is in line with the emerging wisdom that understanding migration behaviour is the best starting place for assessing how climate change will impact on the distribution of human populations[5]. Gray and Mueller's research is exciting because they offer one of the first large-scale analyses (1,680 households) of a longitudinal data set (1994 to 2010), which allows rigorous testing of the statistical effects of floods and non-flood-linked crop failure on population migration. The data set they used is structured to represent rural Bangladesh — one of the countries recognized to be at the sharp end of climate change impacts. No one would doubt that Bangladesh has experienced significant short-term population displacements associated with natural disasters over recent decades. The data set, collected by the International Food Policy Research Institute, allowed the researchers to make the key distinction between household-level effects and community-scale impacts on migration decisions — a distinction that has often been ignored in mobility studies. Gray and Mueller also differentiate between local mobility (moves within a person's district of origin) and long-distance moves. Critically, their research shows that international moves are rare, scorching the myth that climate-related natural hazards are a catalyst to significant population movements towards the countries of the global north.

The main finding of the research is that exposure to flood-related disasters does not consistently increase population mobility, whereas non-flood-linked crop failures mainly stimulate migration at the community level. These are really important conclusions that will be surprising to many environmentalists,

and that merit careful consideration. The findings are in line with migration theory, which suggests that disaster events, through a reduction in the resources available to a household, make it less likely for migration to occur. Longer-distance moves, which are more expensive, will not be a natural consequence of a flood-linked disaster event. By contrast, local mobility, being less expensive and involving less uncertainty as a post-disaster adaptation strategy, will be more attractive to those deciding to move. Complementing these findings is research in other parts of the world that shows that pre-existing longer-distance labour migration patterns are disrupted by natural hazards, with the demand for migrant labour being reduced when cash crops are damaged by a hazard event[6].

One of the fascinating aspects of Gray and Mueller's work is its attention to scale effects. They test the idea that shocks such as floods and crop failures may impact mobility more strongly through the impact on the community at the local district level than at the more immediate scale of the household. Their results show that there is an effect at both levels, but in opposite directions. This outcome is important for policymakers, who often either ignore one level in favour of the other, or assume that community effects reinforce household influences on mobility. In practice, the Bangladeshi case seems to suggest that if a hazard event impacts the household, then the resources necessary for migration are reduced and out-migration is unlikely. It is only if a household is not affected by a natural hazard but is located in a wider community made vulnerable by a hazard that mobility becomes more likely. Why? The answer lies in factors such as loss of employment opportunities outside the household but within the community. The research is therefore significant in providing solid evidence that 'geography matters' in understanding the relationship between climate change and migration. The context within which mobility decisions take place is not simply that of the individual or the household operating in isolation — they are also set within the geography of the wider community, with its social networks and opportunity structures.

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Villagers move home to higher ground following flooding in northern Bangladesh.

The implications of this study when read alongside recent government-funded research, such as the UK Government Office for Science 2011 Foresight report *Migration and Global Environmental Change* are considerable. In contrast to previous policy concerns promoted by environmentalists that climate change will be responsible for significant numbers of 'environmental refugees', the evidence points almost to the inverse outcome. One of the greatest problems for policymakers concerned with climate-linked hazard events is that they reinforce population immobility. This happens among people who to some extent are trapped by the geographical contexts of their livelihoods, which incline them to continue living in environmentally high-risk locations. As Gray and Mueller[4] conclude, decisions to move are nearly always multi-causal, with only the tiniest fraction of those impacted by natural hazards being able to engage in international migration. Policymakers need to focus attention on adaptation policies geared to the reality of population immobility among the vast majority of people in the global south, whose livelihoods have been made more vulnerable by climate change. ❐

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