conditions. With predictions ranging from seasonal forecasts of a heavy monsoon to shifts in rainfall patterns due to climate change, humanity faces two new challenges: not just preparing for the foreseeable climate but also modifying decision-making processes in order to incorporate the availability of new information.

Prediction is not enough

People must both understand and trust warnings, and they must have the capacity to respond in an adequate manner. In the year 2000, the Limpopo river basin in southern Africa experienced a very substantial rainfall for many days as a result of unusual cyclones. Experts knew that it would result in serious flooding – of a magnitude never experienced before by rural communities in Mozambique. Yet very few villages were informed about it.

Most communities had no electricity or radio, yet people had previously been able to successfully predict floods by observing ants. Ants build their homes underground; when groundwater rises, they leave their nests – and people know that the water is rising. On this occasion the flood came so rapidly there was no time for the groundwater to rise, or for ants to react before the river overflowed. When someone who had heard the experts' prediction drove to a certain village to tell them to evacuate, the local chief asked him, "Who are you and why should I do what you say? Since the times of my ancestors, floods have only occurred after ants leave their homes. Now the ants are not moving and you come and ask me to leave?"

As in most of the Limpopo valley, many people did not evacuate. About 700 people drowned. The global climate is changing, and traditional knowledge is increasingly unreliable because our past experience does not necessarily apply to present and future risks. In that light, the key is to learn how to communicate new knowledge about future conditions in ways that can be understood and trusted.

While most people in vulnerable communities have already noticed unusual extreme events taking place, they often explain such events through supernatural forces, such as divine punishment or intervention by angry ancestors. This kind of explanation leads to the belief that things will soon return to normal or to fatalism and inaction. As a Mozambican woman farmer said during a Red Cross workshop: "If God wants to punish me, I will be punished, no matter what I do."

However, that form of thinking can be changed by access to new information. After learning about the very basics of the climate change process and watching a short video on the impacts of more frequent flooding in Argentina and Bangladesh, the same farmer said: "I thought my community was the only one punished this hard, and that it wouldn't happen again. But now I see that women all over the world are suffering in similar ways; so maybe it is true that the rains are changing and will continue to change, and maybe I can do something about it."

Now the cyclone warning system set up by the Mozambican government uses a colour-coded system with flags to label approaching cyclones. The Mozambique Red Cross helped design and implement the system, asking communities about traditional forecasting methods and sharing information about new ways to make predictions. A recognisable system was set up, based on radios, flags and whistles for broadcasting alerts. Escape routes and other response options were identified and publicised at community level. This greatly contributed to minimising human losses during the next intense cyclones to hit the country.

In Colombia, a number of activities were organised around a forum on climate change. In two villages schoolchildren wrote and produced a play about climate change. Communication students at Javeriana University made banners and developed materials for children on what climate change is and what children themselves can do to contribute to preventing climate change and address rising disaster risks. The students also produced a very successful puppet show about the earth being ill and running a temperature; the script, with music, is available in Spanish from the Red Cross/Red Crescent Climate Centre.

Climate change is with us and is already making humanitarian work more difficult. Things are expected to get worse. We will have to be smart and efficient, not just to keep up with the changes but to stay ahead of them.

Maarten van Aalst (MvanAalst@redcross.nl) is Associate Director and Lead Climate Specialist of the Red Cross/Red Crescent Climate Centre. This paper is based on excerpts from the Red Cross/Red Crescent Climate Guide, online at www.climatecentre.org.

Predictive modelling

Christopher Smith, Dominic Kniveton, Sharon Wood and Richard Black

Empirical modelling techniques are the only way to effectively simulate migration resulting from a complex combination of pressures and opportunities.

There is considerable uncertainty in predicting climate change-induced migration. Firstly, we do not know the extent and magnitude of the climate changes responsible for pushing and pulling migrants. Secondly, the individual contexts, perceptions and behaviour of those affected by climate changes vary considerably. An agent-based modelling (ABM) technique can be used to simulate the relationship between the influence of environmental factors, climate variability and change and migration. According to the rules created for a particular simulation,

each 'agent' (representing a person or a household) assesses its personal situation, the climate risk, its ability to act, and the behaviour and views of others and then makes appropriate decisions to achieve its aims.

One advantage of ABM is the understanding that a series of interactions between individuals may result in more complex outcomes than could have been predicted by aggregating the behaviour of many individuals. ABMs are therefore an effective means of analysing the behaviour of individuals who interact but may think and act differently from each other and who also exhibit newly emerging traits. An important feature in the context of climate change is the capability of an ABM to allow scenarios to be simulated for which historical analogues (e.g. experience from past climate events) do not exist.

Migration

In developing an ABM to simulate the impact of climate change upon migration, it is important to consider the influence of social structures, institutional influences and the actions of individuals. When perceived risk from climate change is greater than a specified threshold, the individual considers adaptation and the options available – which may include adaptation or migration, or a maladaptive strategy such as denial or ineffective livelihood adjustments.

The basic cognitive process that each agent undertakes in consideration of climate stimuli, and the resulting selection of adaptation strategies, underpins the formation of the ABM. However, the individual context of each agent's unique combination of experiences, biases, assets and perceptions defines the differences among individual agents and their different responses to both environmental stimuli and the actions of others.

In order to refine the attributes of the agents and the rules of their interaction within an ABM, detailed country-specific knowledge is required.[1] With adequate data from which to develop the rules of interaction and thresholds for action of agents, the response of a community to a given or forecast climate scenario may be undertaken to provide a simulation of how that community will respond on the individual, household and community level. By developing an ABM from comprehensive data, the degree to which recent migratory movements have been affected by climate stimuli can be assessed and the influence of climate isolated from the multiple drivers behind migration.

Developing a model to simulate existing migrant flows provides an opportunity to investigate both the sensitivity of drivers of migration to climate and the thresholds and ranges of climate conditions that lead to migration. As a result of these findings, such a model can also be used to identify scenarios where there is a significant likelihood that communities and individuals will migrate. This could lead to an agent-based modelling approach that can produce a more detailed prediction of the number of people driven to relocate as a result of environmental conditions than has previously been possible.

Christopher Smith (c.d.smith@sussex.ac.uk) is a DPhil researcher and Dominic Kniveton (d.kniveton@sussex.ac.uk) is Senior Lecturer in the Department of Geography, University of Sussex. Sharon Wood (s.wood@sussex.ac.uk) is Senior Lecturer in Computer Science and Artificial Intelligence, Department of Informatics, University of Sussex. Richard Black (r.black@sussex.ac.uk) is Co-Director of the Sussex Centre for Migration Research (www.sussex.ac.uk/migration/).

1. For more details, including information on the existing model for Burkina Faso, please see www.informatics.sussex.ac.uk/users/cds21/publications/

A global research agenda

Koko Warner and Frank Laczko

Given the magnitude of the challenges ahead, we urgently need to develop a policy-oriented global research agenda.

The topic of environmental change, particularly climate change, and migration is exploding onto the global policy agenda. Yet little evidence-based research exists to inform sound decision making. To address the need for more sound empirical research and to identify how to carry forward a global research agenda, the UN University Institute for Environment and Human Security (UNU-EHS) together with the International Organization for Migration (IOM) and the UN Environment Programme (UNEP) brought together 35 experts in the fields of migration and the environment in April 2008. They assessed the current knowledge base and identified research gaps and priority areas for research, which fell within three main areas:

1. Measurement and identification

More work is needed to conceptualise and quantify migration responses to the impact of environmental change and degradation. The existing, speculative estimates about the potential scale of environmentally induced human displacement underline the fact that we know very little about how changes in the environment affect migration and that we lack the data and research necessary to move beyond such estimates. We do not understand well how slow-onset events, including desertification, sea-level rise and deforestation, affect migration within and between countries. Nor do we know much about how expected changes in migration patterns are likely to affect the environment. Policymakers lack the information necessary to prepare for, prevent or respond effectively to environmental migration.