In much of the developing world, food security and environmental change are inexorably linked. **Jodie Harris** meets the people who are bringing scientists and policy makers together to provide sustainable solutions to major resource issues.

Linking glacial melt to food

Fertile soils and a plentiful supply of water – at first glance, many areas of the Indo-Gangetic Plain in south Asia would seem like the ideal place for rural communities to thrive. However, food security in one of the most intensely farmed areas in the world relies on a water supply which is increasingly threatened. At the foot of the Himalayas, this vast plain receives much of its fresh water from thousands of glaciers high up in the mountains. But, our climate is getting warmer, which will affect the melting of the glaciers and hence the reliability of this water source. The key questions are how much, when, and how will this influence food security?

How much and when?

The first two questions have driven Gwyn Rees' research at NERC's Centre of Ecology & Hydrology near Oxford. Having heard alarming predictions of Himalayan glaciers disappearing within the next 40 years, Gwyn teamed up with eminent glaciologists to develop new forecasting techniques which will give us a better understanding of how glaciers are likely to respond as the climate changes. With funding from the UK's Department for International Development, they set up project Sagarmatha – the Nepalese word for Mount Everest – to assess potential long-term changes in the flow of snow and glacier-fed rivers originating in the Hindu Kush and Himalayas. Sagarmatha began in 2001 and marked the first comprehensive attempt to incorporate the dynamic nature of glacial retreat into hydrological models.

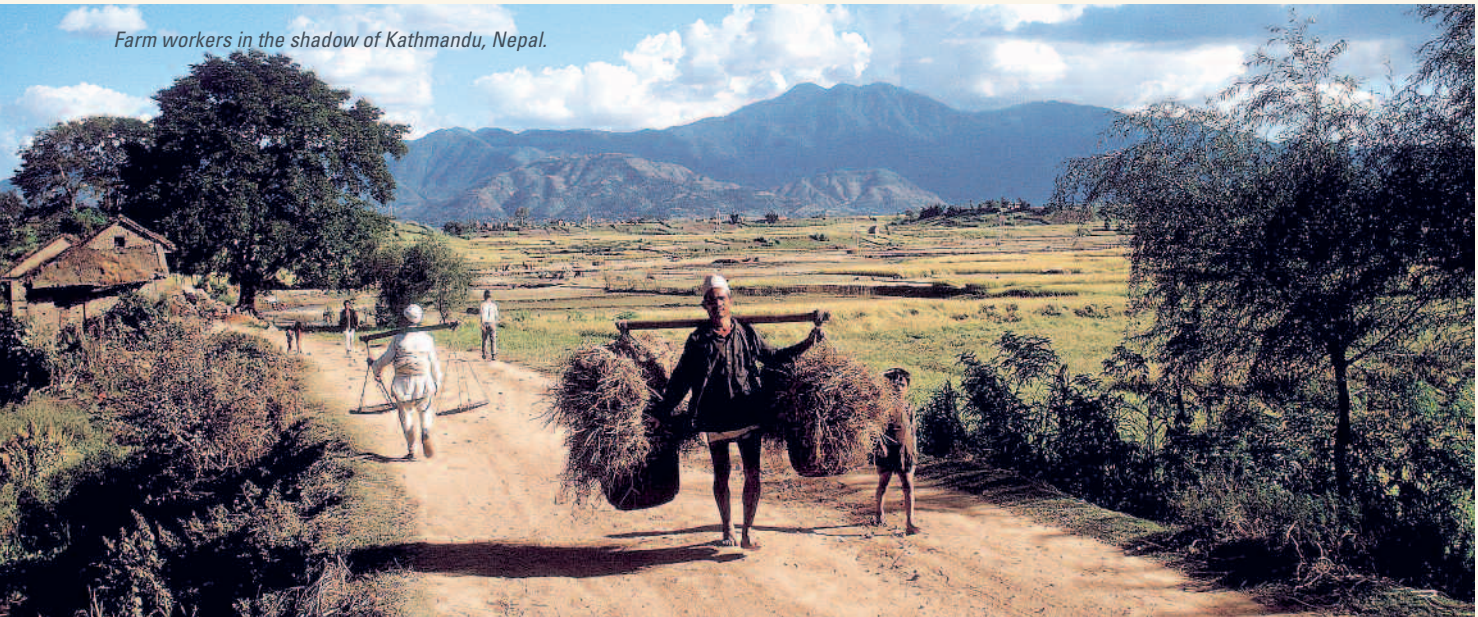
What had not been achieved until now, was a plausible way of representing the retreat of many hundreds of glaciers, all melting at different rates, and their influence on river flow. The researchers' clever solution was to model the hydrology of the whole region by dividing it into grid squares. They amalgamated any glaciers that contributed their melt water to a particular square to form one single 'conceptual' glacier, with a generic shape and depth that was allowed to change over time. The model showed how much fresh water was generated and where it would flow under certain climate change scenarios.

Assuming an average global warming of 3°C per century*, the model revealed that, far from disappearing in the next 40 years, many of the region's glaciers would remain beyond this century. Initially, river flows would increase as they received more melt-water. But as the glacier retreat advanced, the volume of available ice for melting would diminish leading to reductions in flow many decades from now.

The model showed glacial melt could vary quite significantly across the region and this can be largely explained by differences in snow fall which can insulate glaciers, protecting them from melting.

The Himalayan arc ranges from the south-east to the north-west covering Burma, Bangladesh, Bhutan, Nepal, northern India, through to Pakistan and Afghanistan. Every year, the monsoon arrives from the Bay of Bengal in the south-east, weakening as it moves further north and west. In the south-east, glaciers receive a lot of snow that will buffer them from climate warming. Additionally, a high proportion of fresh water runoff does not come from glaciers but from rainfall over the glacier-free part of the catchments. Therefore the net impact of glacial retreat on fresh water resources in the east is not quite as significant as for the countries further west.

The analysis shows that glaciers which supply the river Indus and its tributaries are more susceptible to climatic warming. The Indus provides the key water resource which drives the economy



Farm workers in the shadow of Kathmandu, Nepal.

Terry Fincher Photo Int / Alamy

on our table

of Pakistan. Using the scenario for a 3°C global warming per century, the upper Indus will see an increase in flow followed by a gradual decline to about 40 percent of the original baseline, one hundred years from now. In contrast, analysis for the upper Ganges basin, which supports much of India's agricultural production, predicts that flows will increase for several decades. Only with the very warmest climate scenarios (15°C warming over 100 years) do we see signs of glacial depletion.

Gwyn Rees commented, 'We've shown there are quite serious implications if there are reductions in water availability in the coming decades but these forecasts also suggest that there may still be enough time for the region's authorities to cope with the problem'.

How will this influence food security?

Increasing glacial melt is just one example of the many environmental changes we are likely to witness in coming decades. By combining our knowledge of these changes with what we know of people's ability to cope and adapt, we can begin to estimate the consequences for food security. This is where an international project called 'Global Environmental Change and Food Systems' (GECAFS) steps in – a small research group with a very big challenge. GECAFS is developing methods for assessing the interactions between food security and environmental change by researching the vulnerability of food systems and possible adaptation options. NERC funds the international project office based in Oxford and GECAFS has ongoing work on the Indo-Gangetic Plain.

Food security is hugely complex. Besides environmental factors affecting agriculture, politics, infrastructure, trade, economics, poverty, education, culture and religion all have an influence. GECAFS' science officer Polly Ericksen said, 'Until now, researchers have been mainly looking at the potential impact of climate change or hydrological changes to estimate influences on yield. But crop yield is not the only factor. Our case studies across the region showed that rural populations purchase a lot of food and much of their own food production is sold in markets. So if we want to know how environmental change will affect food security, we need to explore how it will influence other factors such as trade and affordability'.

The important regional differences in glacial retreat, identified in the Sagarmatha project, need to be considered by policy makers to avoid potential food crises. Even though the western regions are more dependent on glacial-fed irrigation and glacial melt is likely to be more pronounced, people here tend to have greater wealth, infrastructure and resources than those in the east. These, together with many other non-environmental factors, will all influence people's ability to cope.

Despite considerable progress, policy makers still need better knowledge of environmental changes in, for example, regional hydrology, sea level rise, and extreme weather events. They also need help integrating and interpreting different scientific results to help them plan for the future. By identifying how environmental factors are likely to influence food security across the region, GECAFS is both helping to raise awareness with policy makers and guide future research. Covering a wide range of science from environmental change to social and economic analysis, the group links research such as the glacier analysis to other important studies. In essence, it is working to ensure that timely, relevant science is put to good use. As John Ingram, GECAFS Executive Officer said 'We see our work as strengthening the bridges between the science, policy and development agendas to help improve food security'. ❖

**Based on the 2001 Intergovernmental Panel on Climate Change (IPCC) report. The latest IPCC report was published in February 2007.*

Gwyn Rees is a hydrologist at the Centre for Ecology and Hydrology, Wallingford. Tel: +44 1491 838800, email: hgrees@ceh.ac.uk. Other Sagarmatha researchers included: David Collins from the University of Salford, Syed Hasnain from Jawaharlal Nehru University, India and Arun Bhakta Shrestha from the Department of Hydrology and Meteorology in Nepal. John Ingram is GECAFS executive officer. Tel:+44 1865 285176, email: info@gecafs.org, www.gecafs.org
Jodie Harris has recently joined as NERC's science writer/web editor.

Global Environmental Change and Food Systems (GECAFS)

- NERC funds the GECAFS International Project Office and the Economic & Social Research Council also provides funding. The programme is running three projects which helps integrate NERC's environmental research into other studies.
- **Indo-Gangetic Plain (featured).** Key issues are water supply; climatic variability; regional differences in food systems; improving agricultural competitiveness; and creating rural employment opportunities.
- **Southern Africa.** Key issues are climate variability; lowland scrub degradation; biodiversity loss; improving rural infrastructure; access to local, regional and international markets; and better safety nets such as the provision of welfare or measures to respond to disasters.
- **The Caribbean.** Key issues are extreme weather; sea conditions; food self-sufficiency; and improving trade policies and competitiveness.