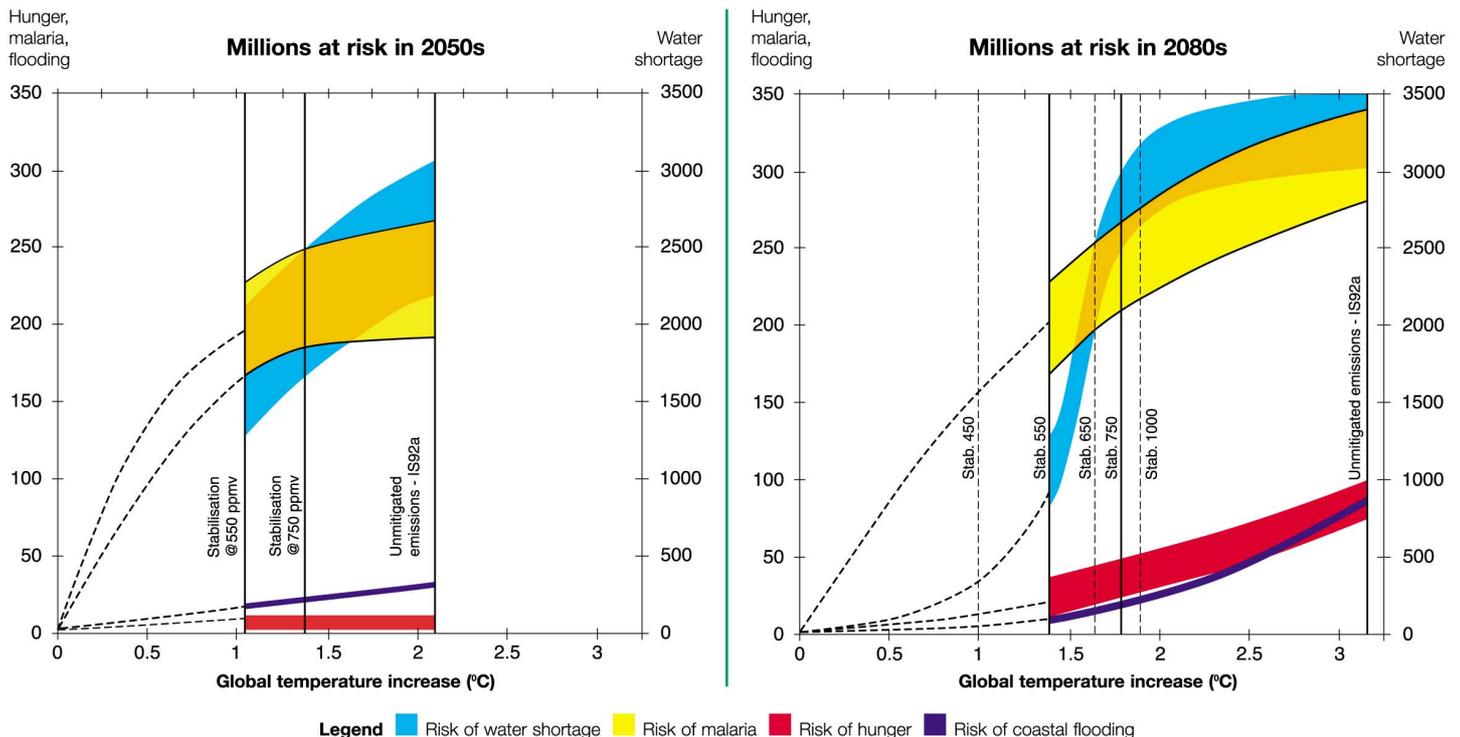# Millions at risk

Defining critical climate change threats and targets
Discussion of the figures from *Global Environment Change* 11:3(2001):1-3

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The figures below provide new information on the additional millions of people who, due to climate change, would be at risk from hunger, malaria, coastal flooding and water shortage:

Curves indicate additional millions of people at risk for given increases in global temperature. The width of the curves indicate one standard deviation around the mean, based on results from four HadCM2 experiments (2,3). Solid lines indicate model-based estimates. Dotted lines are inferred (6) and intended as schematic. Global temperature is relative to 1961-90 average. Vertical lines indicate the temperature increase for emissions scenarios with CO2 concentrations that ultimately stabilise at specified levels.

Agreements to mitigate climate change have been hampered by several things, not least their cost. But the cost might well be more acceptable if we had a clear picture of what damages would be avoided by different levels of emissions reductions, in other words a clear idea of the pay-off. The problem is that we do not. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published this year (1) lists a wide range of potential impacts but has difficulty in discriminating between those that are critical in their nature and magnitude from those that are less important. Yet the identification of critical impacts (e.g. ones that should be avoided at any reasonable cost) is obviously a key to addressing targets for mitigating climate change. Indeed, a central objective of the UN Framework Objective on Climate Change (UNFCCC) is to avoid "dangerous levels" of climate change that could

threaten food security, ecosystems and sustainable development (areas of risk that are specifically mentioned in UNFCCC Article 2).

For several years we have been researching impacts in key areas of risk: hunger, water shortage, exposure to malaria transmission, and coastal flooding, as part of a global fast-track assessment (2). The results of our work have been reported widely and form a significant part of the IPCC's assessment of likely impacts (1). But they are scattered through different parts of the IPCC report and other literature and, before now, we have not brought them together. For this review we have graphed our estimates of effects as a single measure: the additional millions of people who could be placed at risk as a result of different amounts of global warming.

The figure shows the increase in millions at risk due to higher temperatures for two time periods: 2050s and 2080s. The analysis takes into account likely non-climate developments such as growth in population, and income and developments of technology, and these become important assumptions behind future trends in, for example, increases in crop yield and the building of coastal defences. These developments themselves have very great effects on the numbers at risk and represent a (non-climate change) reference case. The graph thus shows the additional millions at risk due specifically to estimated future changes in climate.

But now for the caveats: the reference case is only for one future world (what the IPCC used to call a best estimate or 'business-as-usual' future, now referred to as IS92a). More recently the IPCC has explored a set of six different developmental pathways that the world may follow (3), and the millions at risk in these alternative futures will certainly differ. Our work on these is in hand but will probably take a year to complete. We need also to emphasise that the graph is a global estimate which hides important regional variations and, so far, it is based on one model of future climate patterns (the UK's Hadley Centre second generation global climate model) (4). While these are the only global impact estimates currently available, we need urgently to complete similar ones for different climate models and for a variety of development pathways.

Five important points emerge from this figure. First, the curves of additional millions at risk generally become steeper over time. Less obviously, this results as much from a larger and more vulnerable exposed population in 2080 than in 2050, as from increases in temperature or inferred changes in precipitation and sea-level rise. For example, the remarkable steepness of the water shortage curve in 2080 is the outcome of very large city populations in China and India becoming newly at risk, In the case of hunger, however, the rising curve in 2080 stems from widespread heat stress of crops, while up to about 2050 lesser amounts of warming lead to yield gains in temperate regions that balance losses elsewhere and lead to only small net increases in hunger (2). These complex interactions between exposure and climate change tell a clear story: there will be more millions at risk as time progresses.

Secondly, the figure indicates how much we need to reduce emissions in order to draw-down significantly the numbers at risk. We have estimated effects assuming that atmospheric concentrations of CO_2 are stabilised at 750 parts per million (ppmv) by 2250 and at 550 ppmv by 2150 (5). These are approximately

equivalent, respectively, to 10 times and 20 times the reduction in emissions assumed in the Kyoto Protocol. The 750 ppmv target delays the damage but does not avoid it. By 2080 it would halve the number at risk from hunger and flooding. reduce the population at risk of malaria by perhaps a third and water shortage by about a quarter. But to bring risk levels down from hundreds to tens of millions would require a stabilisation target of about 550 ppmv.

We have also indicated on the graph, but only in a schematic form, the approximate locations of 450, 650 and 1000 ppmv stabilisation pathways and their effect on millions at risk (6). Although impact analyses have not yet been conducted for these stabilisation levels, it appears that the 450 ppmv pathway would achieve very great reductions in millions at risk, although very high costs of mitigation would be incurred. It is precisely this kind of pay-off that needs properly to be analysed.

A third conclusion is that information is now available that can help inform the selection of climate change targets. Thus far these targets, such as Kyoto, have been chosen in broadly a top-down manner, without clear knowledge of the impacts that would be avoided, and that has been partly their weakness. Now we may argue, for example, that in order to keep damages below an agreed tolerable level (for example, a given number of additional people at risk) global temperature increases would need to be kept below a given amount; and emissions targets could then be developed to achieve that objective.

Fourthly, it is clear that mitigation alone will not solve the problem of climate change. Adaptation will be necessary to avoid, or at least reduce, much of the possible damage; and since we need many of the benefits of adaptation today regardless of climate change in the future (e.g. increased drought protection of agriculture, improved flood defences, more efficient use of water, better malaria control), many of the adaptive strategies for climate change can be "win-win".

We need to find a blend of mitigation and adaptation to meet the challenge of climate change. Mitigation can buy time for adaptation (for example, delaying impacts until improved technology and management can handle them); and adaptation can raise thresholds of tolerance that need to be avoided by mitigation (for example, by increasing drought tolerance of crops). Considered separately they appear inadequate to meet such a challenge, but combined they would make a powerful response.

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The authors are contributors to the IPCC Third Assessment.

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