

diseases and weeds, allowing their expansion to new regions as they warm and become suitable habitats. Changes in temperature and precipitation may also influence soil characteristics.

Regional impacts

Impacts on potential yields are likely to vary greatly according to types of climate change and types of agriculture.

In the northern mid-latitude regions, where summer drying may reduce productive potential (eg in the south and central US and in southern Europe), yield potential is estimated to fall by 10-30% under an equilibrium $2 \times \text{CO}_2$ climate by the middle of the next century. Towards the northern edge of current core producing regions, however, warming may enhance productive potential in climatic terms. When combined with direct CO_2 effects, increased climatic potential could be substantial - though in actuality it may be limited by soils, terrain and land use.

There are indications that warming could lead to an overall reduction of cereal production potential in North America and to southern Europe, but increased potential in northern Europe. Warming could allow increased agricultural output in regions near the northern limit of current production in the USSR and North America, but output in the southern areas of these regions could only increase if corresponding increases in soil moisture were to occur; this is at present uncertain.

Little is known about likely impacts in semi-arid and humid tropical regions, because production potential here largely depends on crop-water availability, and the regional pattern of possible changes in precipitation is unclear at present. It is prudent,

however, to assume that crop-water availability could decrease in some regions. Under these circumstances there could be substantial regional dislocation of access to food.

Adaptation in agriculture

In some parts of the world, climatic limits to agriculture are estimated to shift poleward by 200-300 km per degree of warming. The warming-induced upwards shift in thermal zones above mountain slopes could be in the order of 150-200 m.

Agriculture has an ability to adjust, within given economic and technological constraints, to a limited rate and range of climate change. This capability varies greatly between regions and sectors, but no thorough analysis of adaptive capacity has yet been conducted for the agriculture sector.

In some currently highly variable climates, farmers may be more adaptable than those in regions of more equable climate. But in developing economies, and particularly in some marginal types of agriculture, this intrinsic adaptive capability may be much lower. It is important to establish in more detail the nature of this adaptability and thus help to determine critical rates and ranges of climatic change that would exceed those that could be accommodated by adjustments within the system.

Recommendations for action

This study has emphasised the inadequacy of our present knowledge. It is clear that more information on potential impacts would help to identify the full range of potentially useful responses and assist in determining which of these may be most valuable.