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RESEARCH ARTICLE

The global distribution of cultivable lands: current patterns and sensitivity to possible climate change

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ABSTRACT

Aim This study makes quantitative global estimates of land suitability for cultivation based on climate and soil constraints. It evaluates further the sensitivity of croplands to any possible changes in climate and atmospheric CO_2 concentrations.

Location The location is global, geographically explicit.

Methods The methods used are spatial data synthesis and analysis and numerical modelling.

Results There is a cropland 'reserve' of 120%, mainly in tropical South America and Africa. Our climate sensitivity analysis indicates that the southern provinces of Canada, north-western and north-central states of the United States, northern Europe, southern Former Soviet Union and the Manchurian plains of China are most sensitive to changes in temperature. The Great Plains region of the United States and north-eastern China are most sensitive to changes in precipitation. The regions that are sensitive to precipitation change are also sensitive to changes in CO_2, but the magnitude is small compared to the influence of direct climate change. We estimate that climate change, as simulated by global climate models, will expand cropland suitability by an additional 16%, mainly in the Northern Hemisphere high latitudes. However, the tropics (mainly Africa, northern South America, Mexico and Central America and Oceania) will experience a small decrease in suitability due to climate change.

Main conclusions There is a large reserve of cultivable croplands, mainly in tropical South America and Africa. However, much of this land is under valuable forests or in protected areas. Furthermore, the tropical soils could potentially lose fertility very rapidly once the forest cover is removed. Regions that lie at the margins of temperature or precipitation limitation to cultivation are most sensitive to changes in climate and atmospheric CO_2 concentration. It is anticipated that climate change will result in an increase in cropland suitability in the Northern Hemisphere high latitudes (mainly in developed nations), while the tropics will lose suitability (mainly in developing nations).

Key words agricultural land, climate change, climate impact on cultivation, cropland, global, land suitability, land use.

INTRODUCTION

Since the emergence of agriculture almost 10 000 years ago, humans have derived a steady source of food supply from cultivation. Currently, about 12% of the land surface (18 million km^2, roughly the size of South America) is under some form of cultivation (Turner *et al.*, 1993; Ramankutty & Foley, 1998). However, a large part of the land surface is unsuitable for cultivation, due to limitations in growing season length, precipitation and soil moisture, soil characteristics or topography. Humans have overcome these limitations to some extent, through the use of irrigation and fertilization and terracing of the land surface.

Ultimately, crops are critically dependent on climate. They need an adequate growing season — warm temperatures for a sufficiently long time — for successful completion of all stages in their life cycle: germination, growth, floral initiation, grain filling and maturity. The boreal regions are normally too cold for cultivation, the temperate zones have sufficiently warm periods for many crops, while the tropics have adequately warm temperatures throughout the year (Cramer & Solomon, 1993; Leemans & Solomon, 1993). Crops are also dependent on an adequate supply of soil moisture. In fact, because the tropics have sufficiently warm temperatures throughout the year, cultivation is determined strongly by the distribution of

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