



## The new competition for land: Food, energy, and climate change<sup>☆</sup>

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### ABSTRACT

The paper addresses the new competition for land arising from growing and changing demand for food when combined with increasing global demand for transport energy, under conditions of declining petro-chemical resources and the urgent need to reduce greenhouse gas emissions. The paper starts from the premise of a 'food, energy and environment trilemma' (Tilman et al., 2009), where all demands to expand the area of cultivated land present high risks of increasing the carbon footprint of agriculture. Having reviewed the main drivers of demand for food and for liquid transport fuels, the paper weighs the controversies surrounding biofuels arising from food-price spikes, the demand for land, and consequent direct and indirect land-use change. It suggests that we need a more complex, and geographically differentiated, analysis of the interactions between direct and indirect land-use change. The paper then reviews evidence of land availability, and suggests that in addition to technical availability in terms of soil, water, and climate, political, social, and technological factors have significantly shaped the competition for land in different global regions, particularly the three major biofuel producing ones of the USA, Brazil and Europe. This point is further developed by reviewing the different innovation pathways for biofuels in these three regions. The main conclusion of this review is firstly that any analysis requires an integrated approach to the food-energy-environment trilemma, and secondly that strategic political direction of innovation and sustainability regulation are required to bring about major shifts in agriculture leading to sustainable intensification of cultivation (Royal Society, 2009), rather than the continued expansion of cultivated area. The consequent perspective is one of considerable global variety in technologies, agricultural productive systems, and use of natural resources. This contrasts sharply with the world of a dominant global and integrated technology platform based on petro-chemicals to which we have become accustomed.

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### Introduction: the new competition for land

During the 21st century, land as a global resource is likely to become the focus of intensified competition from a variety of uses. Moreover, the competing uses are likely to become subject to increasing controversy, in terms of the claims made by those promoting those uses, and in terms of potentially conflicting national, regional and global interests. The main focus of this paper is to consider these developments in the light of two underlying drivers for increased competition for land: the increasing demand for energy, particularly with respect to transport (terrestrial and air); and the increasing demand for food, both to meet growing world population and in meeting changes to, and improvements in, nutrition and quality of food.

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Some recent debate has staked a primacy of claim over land use for production of food (World Bank, 2008; FAO, 2008; OECD-FAO, 2008). However, failure to address the demand for energy and materials, in particular to develop alternatives to counter the depletion of petro-chemical resources, will inevitably result in major economic and social disruption on a global scale. We restrict ourselves here to considering the implications for demand for land arising from developing alternatives to oil, rather than energy demand overall. Enhanced and sustainable social welfare will depend on developing new forms of agricultural production of both energy and food, highlighting the significance of 'the sustainable intensification of global agriculture' (Royal Society, 2009; Pretty, 2008; Godfray et al., 2010). We focus on issues raised by the new competition for land<sup>1</sup>, particularly in relation to food, energy, and climate change, rather than the increasing demands for the production of food as such. This paper thus places the competition for land in the framework of the 'food, energy and environment trilemma'

<sup>1</sup> For shorthand, when referring to land, the water resources required for the associated agriculture are taken as included.

(Tilman et al., 2009). For this reason, it starts from a different premise than the Gallagher Report (Renewable Fuels Agency, 2008), with its focus more narrowly on climate change mitigation, biofuels, and land. The new competition for land arising from the trilemma is represented in Fig. 1, each component of which is then briefly described.

#### Food, land and climate change

Although much attention on reducing GHG emissions has concentrated on the use of fossil fuels, there has recently been growing recognition of land-use as a source of GHG. In overall terms, including both land conversion and current agricultural land use, contributions to greenhouse gas emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) are globally estimated to be at least two and a half times greater than the total emissions from global transport (IPCC, 2007; World Resource Institute, 2005). Consequently, any increased production from land to meet the double demand for food and energy/materials must do so sustainably, without further exacerbating anthropogenic climate change. 'Feeding the nine billion' faces a double challenge of restricting GHG emissions both from land-use change arising from expansion in cultivated areas, and a radical change in technology from that employed by current crops and cultivation (Royal Society, 2009; Godfray et al., 2010). For example, although much attention has been paid to the enhanced demand for meat as a source of greenhouse gases, it should also be remembered that rice is a major global contributor to emissions of methane, 20 times more powerful than CO<sub>2</sub> in its greenhouse effect (IPCC, 2007). There is thus a potentially vicious spiral of increased land use, increased global climate change risk, and decreasing availability of land cultivatable at high levels of productivity.

#### Oil, biofuels and biomass

The assumption that increased energy and materials demands will increase competition for land is based on the presupposition firstly that petro-chemical resources will become less available and at increasingly higher and volatile cost, and secondly that substitutes for fossil fuel transport energy and chemical building blocks for materials will be met in significant measure only by biofuels and industrial biotechnology. Liquid transport fuels are, and

will continue to be, the only technology for aviation, now and in the foreseeable future. As will be shown below, they are likely to be the principal form of energy for terrestrial transport for decades to come, given the growing global vehicle fleets dependent upon them. Declining petro-chemical resources will increase the demand for biomass, and hence demand for land allocated to meet this demand.

#### The new competition

When increased demand for food and energy combine, pressure on land conversion is increased, leading to further climate change, which in turn may affect productivity and availability of land, so creating a potential vicious circle. That is the trilemma challenge.

Given the urgency and radical changes needed to meet the food-energy-environment trilemma, new modes of economic governance are emerging, but piecemeal and gradually, nationally, regionally, and internationally. Arguments will be presented that both 'business as usual' and, consequently, 'innovation as usual' are unlikely to adequately meet these challenges. A major shift in the political governance of market economies will be necessary. On the one hand, sustainability regulation, significantly pioneered with respect to biofuels, needs to be developed to encompass all land-based production and consumption, in order to avoid major distortions and deleterious consequences. On the other hand, the evidence is now overwhelming that strategic direction and orientation of innovation to meet these challenges requires the development of novel policy instruments to meet long term goals of transition from the fossil resource economy. This requires both prioritisation of developing the science base in strategically relevant areas, and strategic support for investments in innovation oriented to the sustainable intensification of agriculture for food, energy, and materials, biorefinery, and industrial biotechnology. Political governance requires both sustainability regulation and innovation orientation, in order to bring about long term structural change. The paper suggests that, in contrast to the petro-chemical epoch, the new world will be much more technologically diverse, different regions and nations following different courses, so presenting yet more challenging prospects for international consensus and coordination.

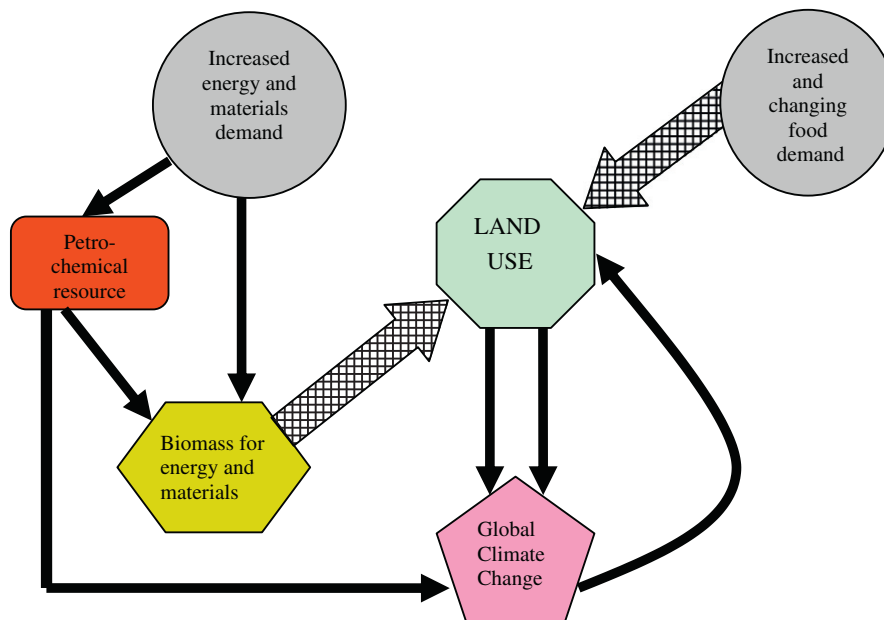


Fig. 1. The new competition for land use: interactions and feedbacks.

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