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Food, Feed, Fuel, Timber or Carbon Sink? Towards Sustainable Land Use

A Consequential Life Cycle Approach

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Chapter 1
Introduction

Buy land, they're not making it anymore.

Mark Twain

Abstract Concerns over global climate change, biodiversity loss and degradation of ecosystem services have led to interest in using land in ways that mitigate these threats, particularly by growing various forms of energy crops to displace fossil fuels. In view of the competing demands on land to feed people adequately, mitigate climate change and sustain biodiversity and ecosystem services, there is a clear need for a systematic basis for allocating land to the competing uses with respect to economic and environmental objectives. The purpose of this study is to formulate an integrated environmental and economic sustainability assessment for comparing different land use strategies for food, feed, fuel, timber and carbon sink. The comparison should be carried out by analysing the systems within a wide boundary, so that it includes consequences in other parts of the world. The focus is the cultivation of crops for different uses and the subsequent displacement they cause. This requires methodological developments for the estimation of substitution effects. Life Cycle Assessment (LCA) is proposed for the environmental assessment, which requires the development of LCA methodologies and characterisation factors for assessing land use impacts on global climate change, ecosystem services and biodiversity. A parallel economic assessment is proposed to be integrated with LCA, also using a life cycle perspective.

Keywords Land use · Climate change · Ecosystem services · Biodiversity · Life cycle assessment (LCA)

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1.1 Background and Rationale

1.1.1 Land Productivity

Throughout human history, land use has become progressively more intensive in order to support an extraordinary human population growth, particularly since the industrial revolution when fossil energy resources supplanted “renewable” sources, mainly wind, water and bio-based. Increases in the productivity of land have even led to a view, almost certainly transient, that land availability is not a constraint on human activities, a view encouraged by general improvements in technology which have resulted in increased production of food and other biomass per unit of land. However, high growth rates of the human population emphasise that land is a finite resource with a limited carrying capacity, a potential problem first identified by Thomas Malthus (1798).

Global average yield for the three most important staple food crops (wheat, rice and maize) increased between 1961 and 2008 (by 183%, 131% and 163%, respectively), despite some inter-annual fluctuations (see Fig. 1.1), but yield growth rates now seem to be declining, indicating the possibility of a “peak” in the near future at which the maximum rate of global food crop production will be reached and after which it may even decline (see Fig. 1.2).

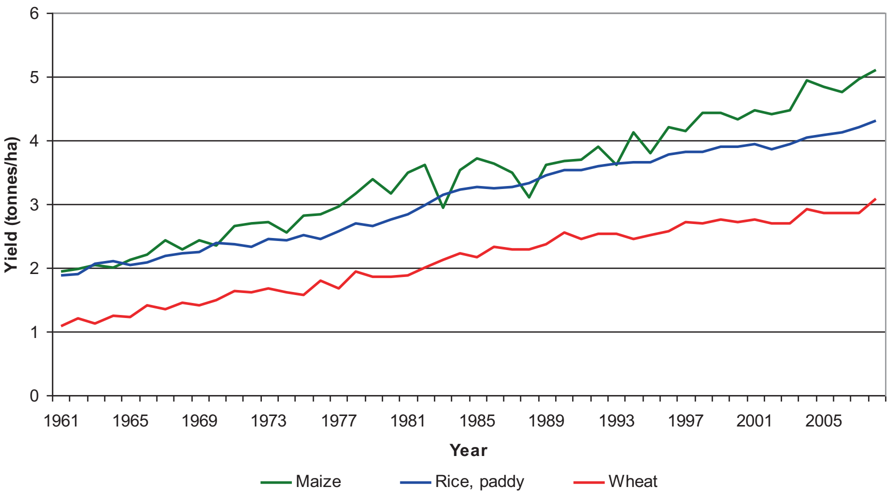

Fig. 1.1 Global average yield of maize, rice and wheat between 1961 and 2008. (FAOSTAT 2010)

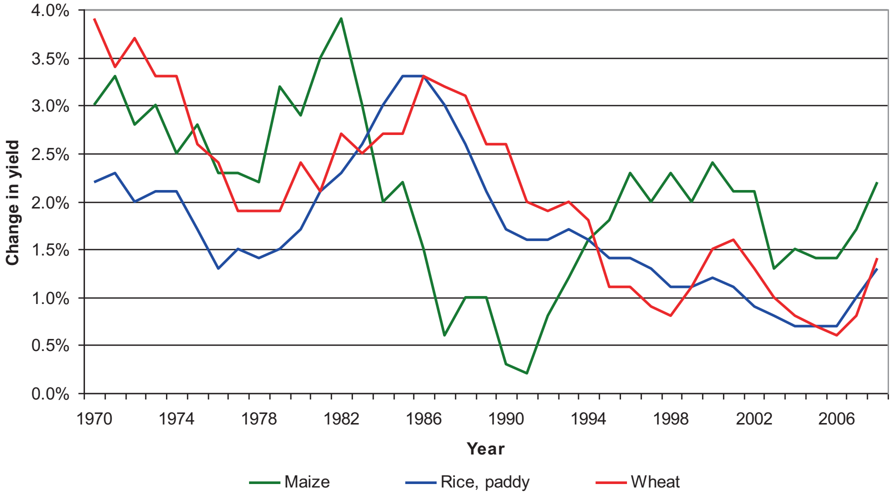

Fig. 1.2 Cereal yield growth rates (Note: Data represent the average annual percentage increase in yield between successive rolling five-year periods (e.g. data for 1970 refer to the increase in average yield comparing 1966–70 with 1961–65; FAOSTAT 2010)

1.1.2 Food Security and Competition for Land Use

There is a tension between the Malthusian view that population growth will outstrip land productivity and the counter "cornucopian" view (Chenoweth and Feitelson 2005; Lomborg 2001; Meadows et al. 2004), exemplified by many optimistic biofuel studies (e.g. Lywood et al. 2009), that the growth in productivity illustrated by Figs. 1.1 and 1.2 can provide sufficient food and fuel. However, the cornucopian view must be constrained. This view seems to be unfounded, since technological progress cannot enable yields to grow indefinitely. In addition, most of the best and most productive land is already under production and, therefore, it is arguable that marginal yields will be lower than current yields. This is particularly the case in economically-developed countries, although developing and emerging economies still have large pools of land to bring into economic production (through, e.g., deforestation) where yields could be as high or higher than current ones. This argument will be elaborated on in Chap. 3.

In addition to the demand for food to feed an increasing human population, land is increasingly required to provide other materials and energy. A multitude of underlying and interrelated factors – such as demographic growth and affluence – contribute to the overall increase in the quantity of land products demanded, exemplified by increasing consumption of meat and dairy produce in China and India. This has led to an increase in food commodity prices and, in turn, to decreased food security (see Fig. 1.3).

Concerns over energy security, global climate change and loss of ecosystem services and biodiversity have led to interest in using land in ways that mitigate these

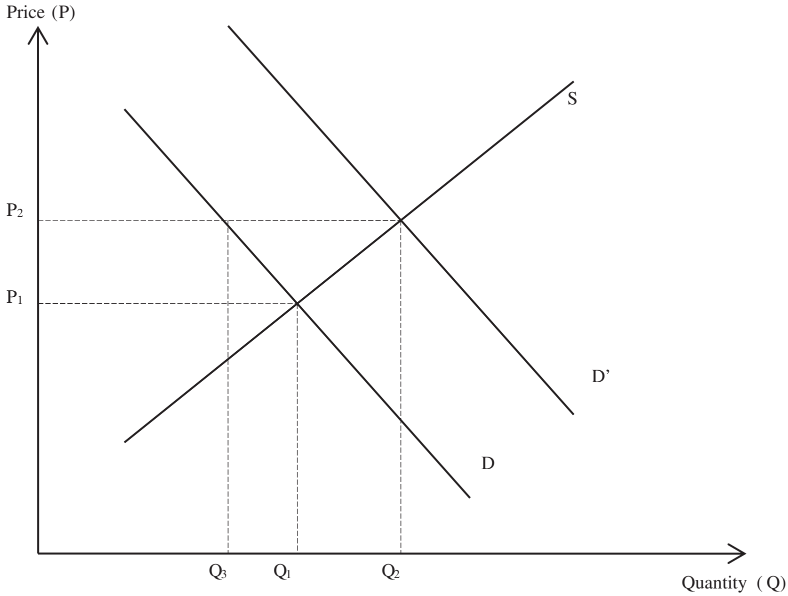

Fig. 1.3 Increased crop demand leading to increased crop prices

threats, particularly in growing crops to displace fossil fuels or to sequester and store carbon, without compromising economic objectives.

With the objectives of reduced greenhouse gases (GHGs) emissions associated with energy use, coupled with increased energy security, ambitious plans to promote bioenergy use have been developed with targets set in terms of percentage of energy or fuel used. These plans imply that land use for production of bioenergy will grow, with resultant pressure on food production and prices and adverse consequences for food security.

In terms of conventional economic analysis of supply and demand, Fig. 1.3 shows that promoting biofuels will shift the demand curve from D to D′ (increased crop quantity demanded from Q_1 to Q_2) which, in turn, will raise the overall cost of crops (from P_1 to P_2). Consequently, the quantity of food consumed will decrease (change from Q_1 to Q_3). However, the demand function may be steeper if one assumes an inelastic demand (as, unlike luxury products, food products are necessities whose demand is less sensitive to price fluctuations). Similarly, a more elastic (lower gradient) supply curve would result in a lower price increase than that shown on the figure and, hence, in a lower decrease in food consumed.

Thus, shortages of food supply have partly been created by increased demand for biofuels, as land that is used for energy will not be available for food production. Competition for land between food and energy crops is therefore a serious issue because it might decrease the potential for food production but, most importantly, it will raise the price of food (see Fig. 1.3). Figure 1.4 shows changes in the annual

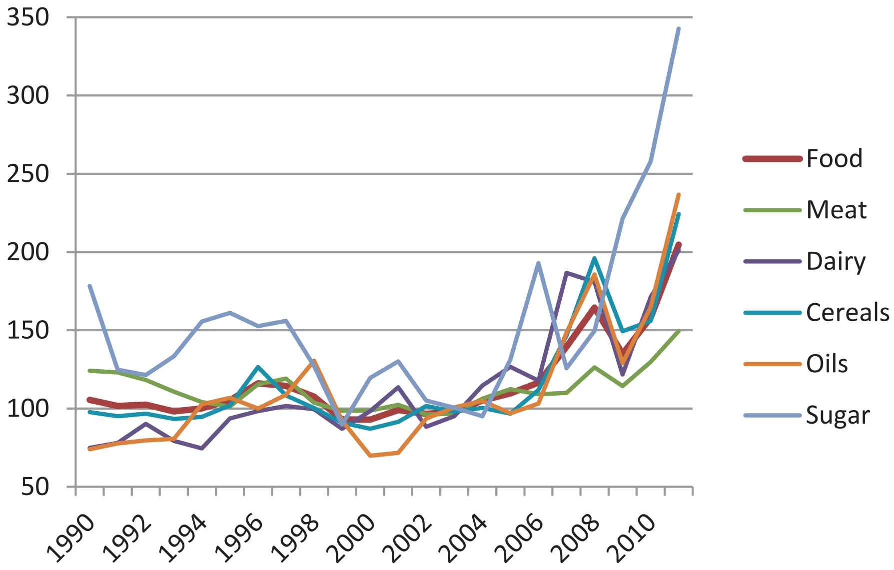

Fig. 1.4 Annual real food commodity price indices (2002–2004 = 100). (FAO 2011)

international real prices of major food commodities. Real food prices in 2011 are more than the double than those in the reference period 2002–2004.

The price of food is arguably a more critical determinant of food security than food availability *per se*. A policy research working paper for the World Bank (Mitchell 2008) concluded that the most important factor behind the rapid rise in food prices in Fig. 1.4 was the large increase in biofuel production in the US and the EU. The production of first-generation biofuels ought to be questioned due to its potential negative effect on food security – a basic human need.

1.1.3 Energy Security

At present, our society is heavily dependent on fossil energy resources to power economic processes. The excessive reliance on imports from politically-unstable regions of the world has exacerbated the need to secure energy from less risky sources. Furthermore, at current rates of consumption, proven and conventional reserves (i.e. those that can be economically produced with current technology) of coal (616 GtC), oil (142 GtC) and gas (70 GtC) are sufficient to last 119, 48 and 63 years, respectively (BP 2010; IEA 2009).

1.1.4 Climate Change

The potential threats arising from climate change, as well as its anthropogenic causes, are now widely recognised. The Intergovernmental Panel on Climate Change (IPCC) and former US Vice-President Al Gore were awarded the Nobel Peace Prize for their achievements in this area, and much of the world is now engaged in a common endeavour to tackle climate change.

There is increasingly compelling evidence to substantiate the argument that potential climate change is related to increasing concentration of anthropogenic Greenhouse Gases (GHGs) in the atmosphere (see Figs. 1.5 and 1.6), and is the

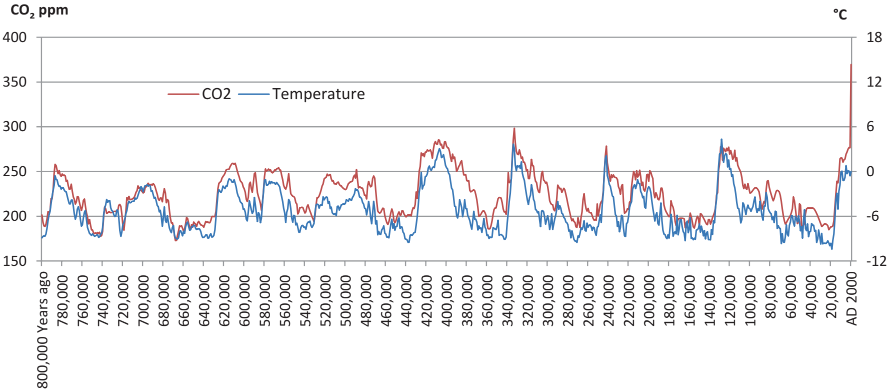

Fig. 1.5 Atmospheric CO2 concentration by volume and temperature deviations from the average of last 1000 years in the last 800,000 years. (Mulvaney 2010)

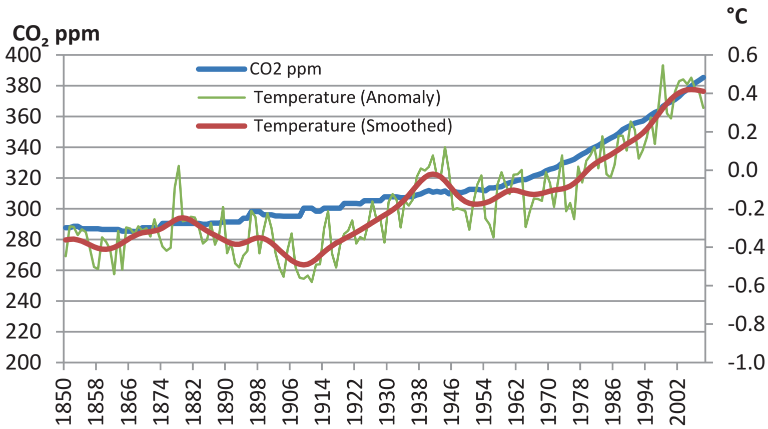

Fig. 1.6 Atmospheric CO2 concentration by volume and temperature deviations from the average of 1961–1990 since 1850. (Met Office Hadley Centre for Climate Change and Climatic Research Unit at the University of East Anglia 2009)