Two consecutive publications of The Royal Society appeared in February 2008. These are entitled Sustainable agriculture I and Sustainable agriculture II (Philosophical Transactions of The Royal Society. 363, No.1491, 443-680 & 363, No.1492, 681-913, Eds: Pollock, C. , Pretty, J. , Crute, I. , Leaver, C . & Dalton , H.). These publications include 31 papers in which the various authors use a total of over 3000 references to other works. The papers present potential problems to be confronted, approaches that should be adopted, techniques for the longer term development of world agriculture and what should be done to counteract the effects of climate change in the presence of an ever-growing world population.

The subjects covered include plant and animal breeding, genetics and diseases, ecology, conservation, bio- diversity and essential intensification, pests, weeds and land management; modelling for the necessary changes in global agriculture, water use, nutrient management, pollution and biotic and abiotic interactions with soil health and ecology, greenhouse gases and C- sequestration and many other issues.

The document indicates that the present rate of total world food production is adequate in energy terms, excluding the problems associated with distribution and regional climatic adversities. World food production has grown by 145 % since 1960, during which time world population has increased from 3 billion to 6 billion.

However, since the 1980s this productivity has been at the expense of usable global stores of carbon. Over the past 30 years, increasingly the demands on the biosphere have exceeded the biosphere's regenerative capacity. In 2003 this was so to the extent of 23 %, whereas in 1961 humanity demanded only half the biosphere's total capacity for regeneration. Man's ecological footprint has grown by more than 700 % since 1961. Our resources have been harvested, especially by deforestation, and wastes have accumulated, for example, as atmospheric carbon dioxide equivalents, CO2-eq.

Agriculture occupies 37 % of the world's land surface and accounts for 80-90 % of water use by humans. Agriculture and agro-forestry have major roles to play in influencing climate change, as those activities release to the atmosphere significant amounts of CO2, CH4 and N2O and agriculture accounts for 52 % and 84 % respectively of the global anthropogenic CH and N O 42 emissions. Smith, Martino et al state that the global technical mitigation potential from agriculture (excluding fossil fuel offsets from biomass) by 2030, considering all gases, is estimated to be 5500-6000Mt CO2- eq.yr-1, but the economic potential will vary with carbon price per t CO2- eq.

Agriculture is the main world-wide source of greenhouse gases. The issue is how should agriculture be managed so that output increases to match population growth over the next fifty years, whilst its contribution to greenhouse gases is reduced in a way for which the costs are acceptable. This is defined by mitigation strategies. Mitigation is limited by finite ecological sequestration and by "a limited market penetration potential of capital intensive strategies, like biofuels".

The sequestration capacity is assumed to be saturated after 50-100 years and likely to be less than the sink of remaining fossil fuels. Smith, Martino et al have produced data for the relationship between the marginal reduction in greenhouse gas emissions and its costs of implementation. This is described as the mitigation achieved for a given carbon equivalent price, defined by "a marginal abatement curve (MAC) for each agricultural practice in each region". Carbon prices up to 20, up to 50 and up to 100 US$ t CO2-eq-1 are assumed. Although agriculture has the potential to offset, at full biophysical potential, about 20% of the total annual CO2 emissions, the likely offsets are 5% to 14% over the price ranges proposed. Of these total mitigation potentials approximately 89 % is from reduced soil emissions of CO2, approximately

9 % from mitigation of methane and approximately 2 % from mitigation of soil N2O emissions. If high C prices obtain, the mitigation potential from biomass energy far outstrips that from food production, assuming adequate food production. The importance of the adoption of husbandry procedures that maximise economic net annual mitigation is absolutely essential, whilst producing adequate crops; but there is a finite limit to the quantity of C-equivalent that various soils can retain

(saturation). Once that limit is reached no further annual mitigation can be achieved for that soil. Practices such as agro-forestry should extend that limit in appropriate cases.

Smith, Martino et al have made a brave attempt to quantify agriculture's capacity to contribute to the containment of climate change. There are "barriers to implementation which may not be overcome without policy/economic incentives" (extremely unlikely to be without these). Although the likely demands of increasing world population are reasonably predictable, the rate and effect of climate change and its influence on agricultural production cannot be predicted with any degree of certainty for any world region. The degree to which world agriculture, especially in developing regions, can be expected to adopt management systems to bring about mitigation, especially important in Asia and South America, at increased cost may be doubtful without a concerted world- wide agreement. The value of this review must be in pointing to those changes in agricultural systems, subject to repeated review, that should have the greatest impact on mitigation and have the most benefit to sustainable agricultural and agro- forestry production over the coming decades, whilst increasing food production. The quantitative values produced are less reliable- although uncertainty ranges are given.

The two volume review is an important contribution to our comprehension of what needs to be done. "What is missing is an adequate account of the social and economic drivers that will determine how the system will respond – the central questions remains how society will balance the demands it places on the resource base with the availability of such resources." (personal communication, Professor Sir John Marsh).

The Introductions to the two volumes effect definitions of the term "sustainable" as "processes that can maintain the required level of output in a way that compromises future capacity as little as possible--- and (that) do what is feasible to protect the long-term future, the production capacity and ecological well being of the land. ----sustainability both in terms of optimizing inputs and management and in terms of mitigating adverse impacts, including those involved in climate change". However, as the editors state that "agriculture in the twenty-first century will have to be very different from agriculture in the twentieth century", the term 'sustainable' seems to carry with it the implication of continuous change. 'Sustainable' has a variety of definitions and as it is impossible to choose an agricultural system which will remain economically efficient for the next several decades it is perhaps not the best term to employ in a scientific treatise. It could be argued that the present malnutrition of much of the world will remain sustainable- perhaps the words 'desirable' would be marginally better.

The two documents represent an important contribution to the debate and one hopes that world policy makers will take action consistent with the conclusions reached. Nevertheless, as consumption by the individual rises, it is also probable that without a halt to population growth world prospects are bleak.

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Comments