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# Sustainable soy biodiesel

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ABSTRACT

The sustainability goals for soy biodiesel are to contribute to energy security by providing a domestically sourced fuel, to maintain and enhance the natzural resource base and environmental quality, to produce an economically viable fuel, and to improve the quality of life. Sustainability is more than just greenhouse gas savings. The main aspects of sustainability of soy biodiesel are environmental, economic and social effects of production and use. The intent of this paper is to identify the major sustainability concerns associated with specific resource use and the potential environmental and social consequences of widely deployed and expanded commercial production and use of soy biodiesel and to explore the opportunities for mitigating these concerns. The ecological and socio-economic consequences of large-scale renewable energy action plans for soy biodiesel are critically considered. This paper is based on the performance and prospects of soy biodiesel production on a global basis as emerging from some 30 life-cycle analyses relative to the main production areas (USA, Brazil, Argentina and PR China).



**Contents**



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## 1. Introduction

The production and use of renewable energy are growing in many parts of the world and countries seek to diversify their energy sources in a manner that helps promote economic development, energy security and environmental quality. The components of a complete bioenergy system include feedstock production, conversion technology, and energy allocation. Modern bioenergy can provide multiple benefits but is also associated with risks. If land use is not well planned and enforced, increased deforestation, loss of peatlands and land degradation can occur, which lead to an overall negative impact on climate change.

Biofuels can represent an environmentally friendly replacement of fossil fuels. Biofuels use is expected to rise from 7 Mt in 2005 to 29 Mt in 2030 (OECD/FAO estimate) [1]. The oilcrops sector has been one of the most dynamic parts of world agriculture in recent decades. Globally, the harvested area in oilcrops expanded by 65 Mha between 1990 and 2005. Oilcrop production is relatively land-intensive. Total vegetable oils production is expected to increase from 138 Mt in 2010/2011 to 180 Mt in 2020/2021.

Global soybean production 2010 amounts to 243.9 Mt, with a forecast of 271.4 Mt for 2012/2013 [2]. The market for soy is determined by demand for soy meal. Global soy meal consumption is estimated to rise from 175 Mt in 2010/2011 to 225 Mt by 2020 (with a market share increase from 55% to 57%). Of the main producer areas only South America has sufficient land reserves to expand soy production significantly. Of the foreseen production growth 70% is expected to be covered by South American producers [3]; *cf.* also Table 3. Since the EU Directive on Biofuels (EC, 2003) [4] came into force there has been a growing concern on the origin of biocrop resources [5,6]. In particular, environmentally friendly replacement of fossil fuels can be questioned at large production scales.

Sustainable bioenergy systems are embedded in social, economic, and environmental contexts and depend on support of many stakeholders with different perspectives [7]. Sustainability and environmental issues of vegetable oils are fundamental in assessing the biodiesel market. Sustainability of biofuels is a controversial issue because of many criteria involved, in particular ecological fragility. Low-carbon fuel policies such as the EU-RED, UK-RTFO and Brazilian Low Carbon Agriculture program (ABC) include minimal sustainability criteria to govern the production of (feedstocks for) biofuels. Consequently, it is timely to reconsider the sustainability of various manufacturing routes based on the best agricultural practice and production technology. It is an objective of this paper to gain insight into the sustainability of soy biodiesel in a global energy system. The paper compares the sustainability of soy biodiesel produced in the United States, Brazil and Argentina and PR China (representing 24% of the global biodiesel market; OECD/FAO outlook 2020).

Agricultural production affects environmental and human health. Agricultural demands have enormous impacts on global ecosystems accounting for 40% of land use and 85% of water consumption. Inadequate policies in agriculture result in potentially negative influences on the environment, including deforestation, soil degradation, over-use of water sources, production of GHGs, pollution from agrochemicals, and destruction of natural habitat and biodiversity. Modern agriculture has masked some significant impacts or externalities, with environmental and health problems documented in USA, Argentina, China and elsewhere [8–10]. The societal burden of these impacts calls for a revision of agricultural policy that shifts production towards methods that lessen external impacts. Ultra-intensive agricultural practices need to be abandoned in favour of a model with enough (not maximised) profitability to make it continuously viable.

Energetic use of biomass offers numerous benefits but also ecological drawbacks. Agriculture can negatively affect the environment through over-exploitation of natural resources as inputs or their use as a sink for pollution. Approximately 30–80% of nitrogen applied to farmland escapes to contaminate water systems and the atmosphere [11]. Agricultural production of biomass for bioenergy is also relatively land intensive, and also partly involves higher transport costs than fossil fuels. There are risks connected with pollution and there is the danger of reducing biodiversity if biomass is cultivated in monocultures. If biomass is used for energy purposes, then the ecological advantages must exceed the negative impacts on human life and the natural environment, such as deforestation, reduction of wild biodiversity, soil erosion, water stress and contamination. Other major hindrances to market penetration of biofuels lie in the infrastructure to move feedstock, biofuels, and fuel blends.

Table 1 illustrates that drastic changes in the overall approach of agriculture are needed, more sustainable with socio-economic and environmental objectives. Priority should be given to sustainable agricultural practices, as also stressed by EU-RED [12]. Sustainable production and consumption are vital for the long-term perspective of global industry and trade. It is necessary to guarantee that biofuels deliver tangible GHG savings compared to fossil fuels. To counterbalance the possible negative effects of net emissions of GHGs, land-use changes, conservation of biodiversity, impacts on food supply and socio-economic impacts various measures have been put in place to ensure their sustainability, *cf.* Section 9. Hobbs et al. [13] describe use of productive but more sustainable management practices.

Sustainability concerns exist due to the relatively low level of resource management (soil, water, pesticides). It is necessary to monitor soil deterioration and declining yields due to nutrient depletion, particularly in hillier land and shallower soils. The economic sustainability of commercial agriculture in marginal ecosystems is yet to be proved [14]. Environmental and ecological sustainability are integrally related to social welfare. In the past, in the field of biofuels policy decisions were made with little regard to the social and environmental consequences [15].

Table 2 lists indicators that express environmental performance of the agricultural sector. However, these indicators are far from ideal; *cf.* Section 9.2. The international Environmental Performance Index (EPI) is an aggregated index, with a set of 22