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## ABSTRACT

This working paper explores the economic, social and environmental context, drivers and impacts of increased demand for Argentine soy-based biodiesel. It is based on extensive stakeholder interviews in Argentina, including those in government, academia and the third sector; participant observation with communities in soy cultivation areas; and review of relevant academic and grey literature. Given Argentina's history of political instability and corruption, plus the adverse GHG implications of clearing native habitats for soy for biodiesel, we are sceptical of the likely effectiveness of biofuel sustainability certification as applied to Argentine soy. Similar problems may apply to other producer countries and a more precautious approach to ensuring that European demand incentivises only environmentally and socially positive biofuel production is justified. This may entail feedstock-specific contracts between producers, trusted intermediaries and retailers, backed by a chain of custody that physically separates certified feedstock, rather than pooling it as an agricultural commodity. Moreover, only feedstocks for which the production characteristics are clearly known and reliably verifiable, and for which the environmental, social and economic impacts are of a high quality, should be incentivised. Civil society needs to be involved in defining what high quality means in this context; currently, soy production in general in Argentina cannot be said to meet this criterion.

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## 1. EUROPEAN POLICY AND RESEARCH CONTEXT

This work is funded under the Systems Theme of the EPSRC Supergen Bioenergy Consortium (2007-11, www.supergen-bioenergy.net/), which is tasked with identifying, modelling and assessing alternative options for UK 2030 bioenergy and biofuel supply. In the UK, the dominant assessment paradigms and values in biofuel policy are managerial: that is, there is an implicit assumption that large scale supply of biofuels is desirable and that the environmental management task is primarily one of mitigating the impacts. This approach is rejected by a substantial proportion of observers, but the views of those in the global South are usually mediated through NGOs in the global North. Moreover, at the time of writing there is little academic material on the topic of biofuel impacts, particularly that incorporating material from interviews with southern stakeholders.

In Europe, biofuels are driven by the Biofuels Directive (2003/30/EC), supported by COM (2006) 34 final *An EU Strategy for Biofuels* and COM (2006) 848 final *Renewable Energy Road Map*. The Directive requires that 'biofuels or other renewable fuels' comprise 5.75% of the energy content of road transport fuels in member states by 2010. In the short to medium term, the use of so-called 'first generation' biofuels (those made from sugar, starch, vegetable oils or animal fats using conventional technologies) is most likely, despite concerns about their sustainability. In September 2008, the European Parliament's Industry and Energy Committee voted for a 5% share for renewable fuels by 2015 and 10% by 2020. However, this support was conditional on at least 20% of the 2015 target and 40% of the 2020 goal being met from "non-food and feed-competing" second-generation biofuels, or from other renewable fuels such as renewably-sourced electricity and hydrogen. This would effectively reduce the 2015 target for the share of EU fuel sales that must be from biofuel to 4%, compared to the target of 5.75% by 2010 set in the 2003 Biofuels Directive (EurActiv.com, 2008).

A limited level of indigenous feedstock production potential within the EU means that much of the production of biomass is expected to occur in the global south (e.g. Hall and Scrase, 1998; Berndes et al., 2003; Doornbosch and Steenblik, 2007). Higher biomass productivity and lower production costs will also encourage production in the tropics. Biofuels therefore have potential to provide opportunities for economic development and improved energy access for developing countries. However, the negative impacts of increased global demand for biofuels are of increasing concern and include direct and indirect land use change, competition with food production and land tenure conflicts (e.g. Doornbosch and Steenblik, 2007; Searchinger et al., 2008; Renewable Fuels Agency, 2008a; Sylvester-Bradley, 2008; Wiggins et al., 2008; Ivanic and Martin, 2008; Semino et al., 2008). Growing concern about the potential negative impacts of biofuels has led to calls for global certification of biofuels in order to ensure that sustainability is a precondition to their production. For example, in order to count toward the EU target, biofuels must deliver life-cycle $CO_2$ savings of initially 35%, then 50% from 2017, rising to 60% when produced from new refineries that come on-stream from 2017 onwards (European Parliament, 2008).

Yet current initiatives to certify biofuels are dominated by institutions from developed countries, and do not necessarily consider the impacts on, or concerns of, a wide range of stakeholders in the South. Considerable doubts remain as to whether such initiatives will be able to address stakeholder concerns and deliver low carbon fuels without jeopardising food security, the environment, or causing adverse social impacts. We return to this issue in the final section of this paper, drawing on what we have learned to date in Argentina and from a substantial (currently unpublished) review of feedstock properties, conducted under Supergen.

## 2. ARGENTINE POLITICAL CONTEXT

No sector-specific policy can wholly be understood without its political and economic history and context, and this is very much the case for Argentina, a resource-rich country with a land area some 11 times that of the UK but two thirds of the population. Argentina is the second largest country in Latin America after Brazil. It benefits from rich natural resources, a well educated population, a strong agricultural sector and diverse industrial base. Argentina covers some 2.78 million $km^2$ and extends 4,000km from the sub-tropical north to the sub-Antarctic south. It has a low population density (13 inhabitants per $km^2$), with almost half of the population of 40.4 million residing in the capital of Buenos Aires.

Argentina's economy is relatively but not solely dependent on commodity exports, with primary goods and processed agricultural products constituting some 57% of export value in 2007, and with manufactured output constituting some 31% of export value in the same year (The Economist, 2005). Argentina has seen Spanish colonisation in the 16th century, federalist independence in the early 19th century and a succession of military regimes and semi-representative civilian administrations through the second half of the twentieth century. It saw high national debt and economic collapse in the early 1980s, followed by liberalising policies that pegged the currency to the US dollar, deregulated commerce and reduced social programmes, instituted in return for assistance by the International Monetary Fund (IMF) (ibid). A decade of rapid economic growth followed under Carlos Menem, followed once more by economic collapse and a change of government, as increasing accumulation of international debt failed to be offset by short-term injections of government revenues from the sales of state enterprises and fortuitous expansion of foreign markets (MacEwan, 2002). As such it exemplified the type of structural IMF reform berated by critics of dogmatic neo-liberal policy (e.g. MacEwan, 2000). In December 2001, Argentina broke contracts with foreign investors, but high global economic growth until just before the time of writing has kept commodity prices high and has again helped stave off further turmoil. With contracting global growth, a high national debt and domestic inflation, agricultural exports will likely remain important to the national economy.

Since 2001, Argentina has experienced fast economic growth. During the economic crisis, the poverty rate doubled to reach nearly 60% of the population but, by 2007, the poverty rate had fallen to 23.4% of the population (World Bank, 2006; CIA, 2009). However, the economic crisis of 2001 has left the Argentinean populace with a deep mistrust in government and the political system. Successive governments have done little to increase transparency and accountability; the government held their first press conference for five years in August 2008. Despite the President Cristina Kirchner's initial popularity, economic difficulties caused by a long running conflict with '*el campo*' (the countryside) and rising inflation have diminished her popularity. It is also widely acknowledged that the national statistics body, INDEC (*Instituto Nacional de Estadistica y Censos*), has been falsifying inflation figures (see for example, the Economist, 2008).

## 3. AGRICULTURE IN ARGENTINA

For many people, the mention of Argentina conjures up an image of extensive cattle ranching, interrupted only by the occasional horse-backed gaucho. Today, however, visitors are more likely to see blankets of green soy stretching as far as the eyes can see. Since the 1970s, when soy was introduced to Argentina's fertile lands, farmers have gradually switched from cattle rearing to the cultivation of soy; a transition which has accelerated since the collapse of the Argentine economy in 2001. The Argentine agricultural sector has always been export-focused, and therefore responsive to market demands, yet the shift from traditional cattle ranching to soy cultivation has been rapid and extensive. Meat and dairy production have been intensified or shifted to the margins, to land that is not suitable for the production of cereals or oil seeds; and there is widespread concern that Argentina will soon become a net importer of milk (e.g. Giarracca and Teubal, 2002). Increasing international demand for agricultural commodities, particularly from Asian markets, has promoted a process of agricultural intensification, characterised by specialisation, productivity and scale (Monti, 2008a; 2008b). The adoption of a technological package, consisting of GM soy, glyphosate, and no-till, has consolidated the use of the current model of production. Agricultural intensification has had wide-reaching repercussions affecting not just the economy and the direction of Argentina's development but also environment and society. Many NGOs are concerned that the current focus on the production of agricultural commodities rather than food has reduced food sovereignty and security. Of the 45.5 million tonnes of soy produced in Argentina in 2007 (FAO, 2008), only 5% was consumed within Argentina, the remainder was exported, principally to Asian markets (beans, flour and oil) and the EU (cattle feed). [Annex A1 provides more information about global demand for soy]. The increasing dominance of the agro-export model, and the resulting specialisation of production, has a knock on effect on the rest of the value chain, further promoting the processing and exportation of agricultural commodities (Monti, 2008a).

## 3.1. AGRICULTURAL EXPANSION

In Argentina, as in many other parts of the world, technological advances have enabled the development of new production systems. With fewer inputs, farmers have successfully increased yields through technological advances, a more knowledge intensive system, and increased financial capital (Monti, 2008b). The use of a 'technological package', consisting of GM seed, no-till and glyphosate (see Annex A2), has consolidated a model of agriculture based on mechanised, large scale production, and has ensured that soy production is economically attractive even though it may not be the most ecologically or socially suitable crop. The cultivation of soy has led to desertification in some parts of the country and to flooding in others (e.g. Monti, 2007; Corregido, 2008), while changes in land management have caused the mass migration of rural communities to urban conurbations.

The production of soy is concentrated in the central provinces of Santa Fe, Buenos Aires, Entre Rios and Córdoba, shown in figure 1. The majority of the soy processing industry is also located in this central region, which enables easy access to the Paraná river- a waterway with deep water suitable for large, export bound vessels.

**Figure 1. Soybean production area, Argentina**

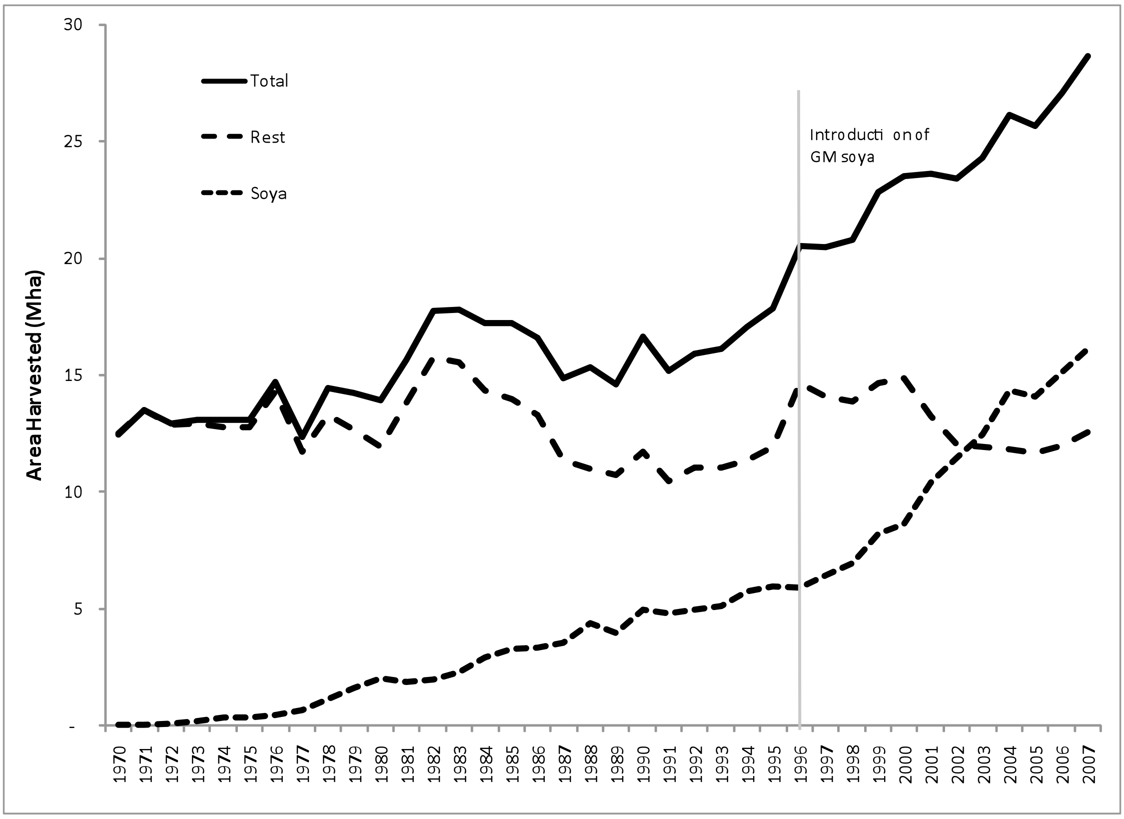

*Adapted from:* Wikipedia Commons

Since the 1970s, the area under arable production has increased from 21 million hectares (Mha) to 32 Mha in 2007 (see figure 2). Increased production of the principal crops- wheat, sunflower, maize and soy- has been due to increased yields in addition to increases in the area under production.

The adoption of GM soy in 1996 led to a huge increase in the area under soy cultivation, from 6.9 Mha in 1996 to 16.6 Mha in 2008 (FAO, 2008). In 2008, soy accounted for more than 50% of the area cultivated with grains (Panichelli et al., 2009). The use of GM soy has also led to increased yields, from 2,105 kg per hectare in 1996 to 2,826 kg in 2008 and similar yield improvements have taken place in other crops (Negri, 2008).

However, the expansion of soy has taken place at the expense of other less profitable crops, while the 'technological package' has enabled production to expand into areas that were previously considered 'unsuitable' due to heavy weed infestations. In the process, the expansion of soy has generated strong pressure on 'marginal' and non-arable areas (Qaim and Traxler, 2005; Monti, 2008b; Zak et al., 2008).

**Figure 2. Evolution of agricultural production, 1970 to 2006 (million hectares)**




*Source*: FAO Stats (2008). Total = 17 principal crops (barley, birdseed, flax, green beans, maize, millet, rapeseed, rice, rye, safflower, sorghum, soya, sugarcane, sunflower, tea, wheat, and yerba mate). The introduction of GM soya is indicated.

*Round-up Ready* (RR) technology was not patented in Argentina and therefore farmers pay only a relatively small price mark-up when they buy RR soy. Farmers are also entitled to use farm saved seeds, unlike farmers in the US (Qaim and Traxler, 2005). The widespread adoption of GM soy has increased profitability for farmers by increasing yields, driving down production costs, and reducing farm labour (see Annex A2).

## 3.2. FEEDSTOCK DIVERSIFICATION

Despite the relative advantages of soy as a biodiesel feedstock outlined above, soy is a relatively low-yielding oilseed crop, producing on average around 500 litres of oil per hectare. This means that vast areas are required to produce smaller amounts than other feedstocks would require. Table 1 provides estimates of the production area required in relation to biodiesel output.

**Table 1. Current production and yields of selected oil crops in Argentina.**

| Crop | Current production (litres) | Current production area (Mha) | Yield (kg/ ha) | Oil content (%) | Oil yields (kg/ ha) | Biodiesel yields (l/ ha) | Production area required (Mha) for a 5% mandate |
|---|---|---|---|---|---|---|---|
| Soy | 40,500,000 | 15.36 | 2,700 | 18 | 486 | 502 | 1.40 |
| Sunflower | 3,800,000 | 2.26 | 1,950 | 45 | 878 | 906 | 0.77 |
| Jatropha | - | - | 2,500 | 55 | 1,375 | 1,419 | 0.49 |
| Castor | 3,200 | 0.001 | 2,500 | 50 | 1,250 | 1,290 | 0.54 |
| Rapeseed | 11,200 | 0.01 | 1,800 | 50 | 900 | 929 | 0.75 |

*Source:* CESPA, 2008

The low yields of soy oil, concerns about overreliance on soy as a biodiesel feedstock, as well as the competing uses for this high value product, are recognised by stakeholders and research is currently underway by universities, companies and government to explore the use of other feedstocks. Jatropha, castor oil, rape seed are all higher yielding oilcrops (Table 1) that would require less land and would therefore add value for investors. The potential of algae to produce biodiesel is also being investigated; Oil Fox, an Argentine company was due to begin biodiesel production from algae in late 2008 (SciDev.Net, 2007). Jatropha in particular has been touted as an alternative biodiesel feedstock, especially due to its ability to grow on 'marginal' lands and studies are underway in the tropical north of the country. However, there is confusion about the legal status of the commercial cultivation of jatropha; while the government has yet to authorise its commercial cultivation, numerous small scale trials are underway across the country. However, all of these alternative feedstocks have their disadvantages. For example, castor oil is expensive and has a poor energy balance, while there is little experience with jatropha, and a lack of knowledge about the crop's pests and diseases. It will obviously take time to develop this knowledge, while extensive experience and expertise in the cultivation of soy already exists in Argentina.

## 3.2. AGRICULTURAL POLICY AND SUBSIDIES

The National Constitution defines natural resources as properties of the provinces, and as a result agricultural (and natural resource) policy is the responsibility of the provincial governments (Lamers, 2006). Currently, there is no national policy or plan for agriculture and the expansion of soy has taken place unplanned and unchecked. The absence of agrarian policies and planning has allowed markets to determine the direction of agricultural development- towards intensification and export, which has increased the sector's vulnerability to fluctuations in external markets. Agriculture is an important sector for economic development, accounting for 9.2% of GDP and more than 50% of national exports; agriculture employs 1% of the population directly, and around 37% indirectly (AAPRESID, 2008; CIA, 2009).

There are no agricultural subsidies at either the national or provincial level, which means that agriculture in Argentina is, in this sense, economically efficient. It is argued by interviewees that those farmers who managed to survive the economic crises of the 1990s and 2001 are by now excellent businessmen, well able to survive and even to thrive in this highly competitive sector. The high cost of agrochemicals means that farmers minimise the amounts they use, unwilling to waste precious resources and reduce profitability. The specialisation and knowledge intensity of these production systems has led to the establishment of a variety of organisations that aim to support farmers, through R&D, networking, training and dissemination programmes. Such organisations include the state run National Institute of Agricultural Technology (*Instituto Nacional de Tecnología Agropecuaria,* INTA), the Association of Regional Consortia for Agricultural Experimentation (*Consorcios Regionales de Experimentación Agricola,* CREA) and the Association of No-Till Producers (AAPRESID). As a result, Argentinean agriculture is characterised by the rapid adoption and diffusion of new technologies and techniques, innovations which may provide the farmer with a competitive advantage. For example, since the introduction of no-till conservation agriculture in the late 1980s, this technique has been adopted by 73% of farmers (AAPRESID, 2008). GM soy, which was first introduced in 1996, today accounts for more than 98% of soy produced in Argentina. However, the prioritisation of short-term economic gains has produced a system which is arguably neither socially nor environmentally sustainable in the longer term.

## 4. THE EMERGING BIOFUELS INDUSTRY

Despite being a relative latecomer to the industry, Argentina is well placed to meet growing international demand for biofuels, and particularly biodiesel. Due to its size and geographical diversity, Argentina has significant bioenergy potential as well as a large, export oriented agricultural sector. Globally, Argentina is one of the top three producers and exporters of vegetable oils, and is the largest global exporter of both soy and sunflower oils (FAO Stats, 2008). In 2007, Argentina was ranked third in a list of countries with potential for biodiesel production due to availability of feedstock (principally soy), low production costs, an export focused industry, and a favourable policy environment (Johnston and Holloway, 2007).

Although Argentina is a major producer of several other crops, such as sunflower and wheat, this review focuses primarily on soy due to its central role in the developing biofuels industry. Similarly, while Argentina has also mandated a 5% blending requirement for bioethanol (based principally on sugarcane) much of the development to date has focused on biodiesel, as does this review. Figure 3 overleaf summarises the soy biodiesel production process.

### 4.1. THE BIOFUELS LAW

In May 2006, the nascent industry was buoyed by the ratification of a Biofuels law (*Regimén de Regulación y Promoción para la Produccion y Uso Sustentables de Biocombustibles,* Law No. 26.093/06; SAGPyA, 2006). The Biofuels law mandates legal blending requirements by 2010 (5% by volume for petrol and diesel), which it is estimated will create a demand for 700 million litres of biodiesel, and 250 million litres of bioethanol (Verhagen, 2007).

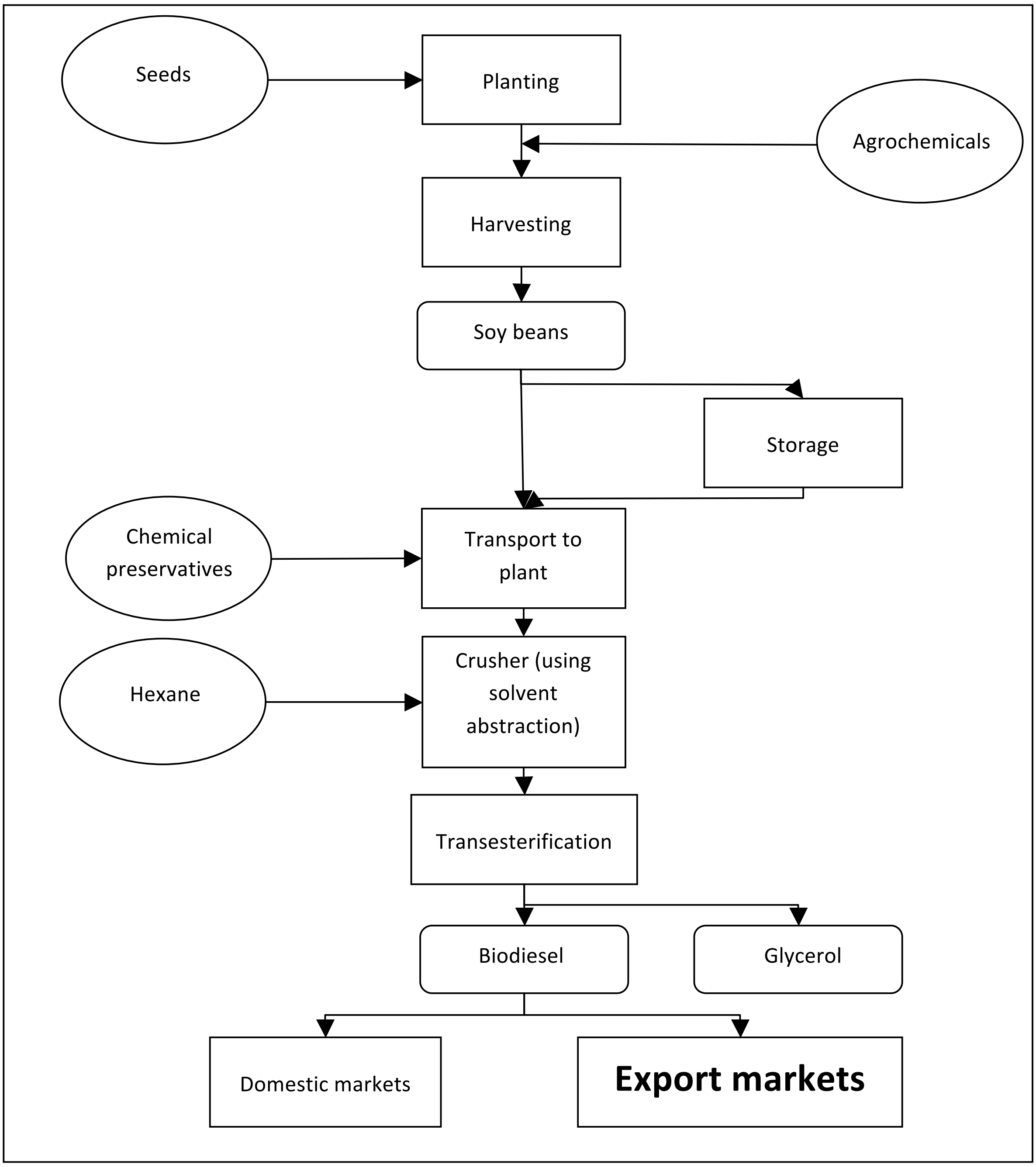
The law aims to prioritise production for the domestic market, and in particular small and medium enterprises (SMEs) in non-traditional production areas. In so doing, the law aims to ensure both security of supply and to provide economic benefits to small producers. Lamers (2006; Lamers et al., 2008) argues that the participation of SMEs in the emerging industry is key to whether or not the industry can be deemed sustainable in a social sense, particularly because it is hoped that SMEs, particularly in rural areas and the Northern regions, will accrue many of the economic benefits.

Companies that produce biofuels will have, besides *autoconsumo* (usually translated as self-supply), two market options: the domestic and the export. While producers who produce for *autoconsumo* and the domestic market will benefit from various tax incentives, production for the export market will not be eligible to receive such incentives (SAGPyA, 2006). However, the domestic market currently has little appeal for large producers who are interested in the more profitable export market and who dominate the agricultural sector. Quality standards, which are currently high as they are based on EU standards, will likely reduce the ability of SMEs to benefit from the development of biofuels (Semino, pers comm.). Therefore, there is considerable doubt about the future direction of biofuels markets in Argentina.

## 4.2. THE ARGENTINE POLICY CONTEXT

Unlike in the EU, the key driver of a biofuel market in Argentina is not reduction of greenhouse gas emissions, but rather economic development. Potential export markets, such as the EU, offer opportunities for increased trade and therefore economic development. Within Argentina, there are large social inequalities; in 2002, following the economic crisis, almost 10% of the population lived on less than US$1 per day, although by 2005 this had fallen to 4.5% of the population (UN Stats, 2008). Contrary to the concern about food versus fuel, current problems with undernourishment are not due to a growing biofuels industry. Indeed, the agricultural sector produces more than three times as much food than is required by the population, however undernourishment is mainly due to 'poor food distribution and the concentration of the agricultural sector' (Lamers, 2006: p.2). It is hoped that the development of a biofuels market will bring rural and other economic benefits. Another policy objective is that of increasing energy security and diversification. Since the economic crisis of 2001, investment in the oil sector has fallen behind increasing demand. Within the next couple of years, Argentina is likely to become a net importer of oil and the government are keen to ensure new energy supplies (Lamers, 2006; USDA, 2007; Lamers et al., 2008). Other important factors are agricultural sector push and differences in export tariffs, which are discussed below.

**Figure 3. Overview of the soy biodiesel production process**




## 4.3. BIODIESEL MARKETS AND ECONOMICS

At present, there is disparity between what the Law is trying to promote, primarily *autoconsumo* and domestic markets, and the biofuel sector that is developing. In order to supply the domestic market, producers are required to register with the government and to meet certain requirements, such as shareholder restrictions and price regulations. The biofuel law has been set up so that a company must choose before it begins construction whether it will supply the domestic or export market. However, by the end of 2008, not one plant had registered to supply the domestic market (CAER, 2008).

Several reasons for the failure to promote the domestic market have been identified. Firstly, the government has yet to determine a price for domestic biofuels yet without strong price signals it will be impossible for potential investors to estimate profit margins. Secondly, the low domestic price of transport fuels due to subsidies means that there is no domestic demand for alternative transport fuels, including biofuels. It is therefore unlikely that biofuels will be cost-competitive with traditional fuels in the absence of subsidies. Finally, although the government has provided demand guarantees, this assurance is worth little in the current economic and political climate. Therefore, investors remain unconvinced that the domestic market represents a viable alternative to the export market.

It is difficult to estimate how much biofuel is actually produced for *autoconsumo*, as biofuels produced to supply this market are produced by small producers who do not sell their products on formal markets. However, CESPA (2007) estimate that an extra 1-2% is produced to supply the *autoconsumo* market.

The economic profitability of soy-based biodiesel is highly variable and profit margins are primarily dependent on the price of the feedstock. Conversion costs (e.g. alcohol, energy, labour, catalysers) account for only around 10% of costs in large plant and between 25-40% in small plant (CESPA, 2007). The economics of biodiesel production are also dependent on the relative prices of oil and soy oil, and market volatility obviously makes it difficult to predict future profits. As stated previously, the vertical integration of biodiesel producers allows them a hedge against price fluctuations. However, it is widely acknowledged that in Argentina, the profitability of soy-based biodiesel is largely due to preferential export taxes, known as *retenciones.*

In order to promote the production of value added products, such as biodiesel, the government has reduced export taxes on such products. Whereas exports of soy oil are subject to export taxes of 32%, biodiesel made in Argentina pays just 14.16% tax; thus reducing the price of local soy oil. For farmers and crushers, it makes no difference if soy oil is sold on domestic or international markets, either way they gain only 66% of the international price (Leone, pers. comm). While the production of biodiesel incurs an increase in production costs of around 10% for large producers, the *retenciones* provide an incentive to produce biodiesel for the export market. Therefore, the small profit margin from soy-based biodiesel is compensated for in reductions in export taxes. In practice, the tax differential is financed by a fall in the incomes of farmers, who receive a lower price for their products.

In March 2008, the Government imposed large increases in export taxes for agricultural commodities; for soy oil, the *retenciones* increased from 32% to a sliding scale that exceeded 50% (CAER, 2008; Mathews and Goldsztein, 2009). This has greatly helped the Argentinean biofuel sector, as those importing Argentinean soy oil for biodiesel production in other countries face a 32% higher cost for the oil than Argentinean biodiesel, such that the sector has grown very strongly since 2006 (St. James, 2008). Argentinean biodiesel exporters do face an export tax, but this is only some 17% after reimbursements and adjustments. Most investors have chosen to sell to the large overseas markets, particularly Europe (ibid).

The Government justified the increased taxes on the grounds that the tax revenues would allow them to address social inequalities and to redistribute wealth from the agricultural sector to average Argentineans. However, these claims were met with widespread scepticism and only caused the unification of a traditionally fragmented rural sector (e.g. Giarracca and Teubal, 2002; Jacques, 2008). Between March and August 2008 roadblocks, strikes and marches brought large sections of the country to a standstill and dramatically reduced agricultural exports. In August 2008, after a lengthy debate in the Senate, the increases were withdrawn. The Government's handling of the *retenciones* crisis has been widely criticised and can be argued to have damaged the country's already fragile economic reputation.

In December 2008, the US eliminated a loophole, which until then had enabled biodiesel importers to receive a US$1 per gallon reimbursement for 'renewable diesel' (CAER, 2008). This loophole, known as 'splash and dash' had enabled traders to import foreign biodiesel and, at port, to add US made biodiesel to the cargo, allowing the entire shipment to qualify for the biodiesel incentive. The shipment would then be exported to Europe at below-market prices. Prior to the closure of the loophole, Argentina was exporting almost 90% of its biodiesel to the US (Origlia, 2009). However, since the end of the US 'splash and dash' policy, Argentina and other biodiesel exporter countries have been to sell directly to the EU, but are unable to compete with US producers who still qualify for the biodiesel subsidy. Production and exports of biodiesel have fallen as a result of the closure of the 'splash and dash' loophole. An uncertain global economic climate and Argentina's worst drought for more than 20 years will also impact on the Argentinean production of biodiesel.

## 4.4. CURRENT AND FUTURE BIOFUEL CAPACITY

Estimates of both current and planned capacity for biofuels vary. The Argentine Association for Renewable Energy (*Cámara Argentina de Energías Renovables*, CAER) recently published a report that has attempted to find out the actual state of play and the estimates given here are largely based on their figures.

In 2008, Argentina produced more than 10% of the world's biodiesel, with sales in excess of US$1.5billion. This made it the world's third largest biodiesel producer after Germany and the US; although the situation is fluid: Germany's biodiesel output has collapsed due to a biodiesel tax and US 'splash and dash' imports (Reuters, 2008). Also in 2008, the total installed capacity increased by 150% from 2007, and similar growth is expected in 2009. The production of biodiesel has increased steady (see table 2) from 155,000 tonnes in 2006, to 585,000 tonnes in 2007 and 1.4 million tonnes in 2008. By the end of 2009, production capacity is expected to increase further to reach 2.4 million tonnes (CAER, 2008). Estimates of production capacity for 2010/ 11 are obviously contingent on future demand and the investment climate; as of the end of 2008, the economic climate has thrown doubt on the development of some of these plants. In table 2, notable increases in production are italicized.

**Table 2. Current and future biofuel production in Argentina, 2006-2011**

| Company | Province | Location | 2006 | 2007 | 2008 | 2009 | 2010/11 |
|---|---|---|---|---|---|---|---|
| Vicentin SA | Santa Fe | Avellaneda | 48,000 | 48,000 | 48,000 | 48,000 | 48,000 |
| Biomadero SA | Buenos Aires | Villa Madero | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Pitey SA | San Luis | Villa Mercedes | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Soyenergy SA | Buenos Aires | Villa Astolfi Pilar | 24,000 | 24,000 | 24,000 | 24,000 | 24,000 |
| Advanced Organic Materials SA | Buenos Aires | Pilar | 16,000 | 16,000 | *70,000* | 70,000 | 70,000 |
| Biodiesel SA | Santa Fe | Sancti Spiritu | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 |
| Renova SA | Santa Fe | San Lorenzo | | 200,000 | 200,000 | *400,000* | 400,000 |
| Ecofuel | Santa Fe | San Martin/ Terminal 6 | | 200,000 | 200,000 | 200,000 | 200,000 |
| Energia San Luisena Refineria, Argentina SA | San Luis | Parque Industrial San Luis | | 30,000 | 30,000 | 30,000 | 30,000 |

| | | | | | |
|---|---|---|---|---|---|
| Louis Dreyfus Commodities, Argentina | Santa Fe | General Lagos | 300,000 | 300,000 | 300,000 |
| Unitec Bio SA | Santa Fe | San Martin/ Terminal 6 | 200,000 | 200,000 | 200,000 |
| Explora | Santa Fe | Puerto San Martin | 120,000 | 120,000 | *240,000* |
| Molinos Rio de la Plata, SA | Santa Fe | Rosario | 100,000 | 100,000 | 100,000 |
| Diferoil SA | Santa Fe | Alvear | 30,000 | 30,000 | *60,000* |
| Ricard Set Energias Renovables, SA | Buenos Aires | Malvinas | 18,000 | 18,000 | 18,000 |
| Hector Bolzan & Cia, SA | Entre Rios | Parana | 7,200 | 7,200 | 7,200 |
| Energias Renovables Argentina, SA | Santa Fe | Piamonte | 6,500 | 6,500 | 6,500 |
| BH Biocombustibles, SRL | Santa Fe | Calchaqui | 4,000 | 4,000 | 4,000 |
| Patagonia Bioenergia SA | Santa Fe | San Lorenzo | | 250,000 | *500,000* |
| Viluco SA | Sgo. Del Estero | Pinto | | 100,000 | 100,000 |
| | Buenos Aires | | | 100,000 | 100,000 |
| Molyagro SA | Cordoba | Tancacha | | 40,000 | 40,000 |
| Sojacor SA | Cordoba | Oncativo | | 40,000 | 40,000 |
| Rosario Bioenergy SA | Santa Fe | Roldan | | 36,000 | 36,000 |
| Santa Fe Bioenergy SA | Santa Fe | Alvear | | 36,000 | 36,000 |
| Fideicomisio Pilar | Cordoba | Rio Segundo | | 20,000 | 20,000 |
| Cooperative Productores del Sur | Cordoba | Jovita | | 20,000 | 20,000 |
| Alimentos Tancacha | Cordoba | Tancacha | | 20,000 | 20,000 |
| La Campania Agroenergia SA | Cordoba | Chalacea | | 20,000 | 20,000 |
| Pronor SA | Cordoba | Obispo Trejo | | 20,000 | 20,000 |
| Agroalimentos | Cordoba | Laboulaye | | 20,000 | 20,000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Laboulaye SA | | | | | | | |
| Exporsoja SA | Cordoba | James Craik | | | | 20,000 | 20,000 |
| Bisudecor SA | Cordoba | Marcos Juarez | | | | 20,000 | 20,000 |
| Agrocereal SA | Cordoba | Viamonte | | | | 20,000 | 20,000 |
| Louis Dreyfus Commodities, Argentina | Buenos Aires | Bahia Blanca | | | | | 300,000 |
| | Santa Fe | | | | | | 200,000 |
| | Santa Fe | | | | | | 200,000 |
| Raiser | Santa Fe | Timbues | | | | | 200,000 |
| ALS Bioenergias SA | Entre Rios | Ibicuy | | | | | 200,000 |
| Goldaracena | Entre Rios | Gualeguaychu | | | | | 40,000 |
| **Total production capacity, yearend (tonnes)** | | | **155,000** | **585,000** | **1,424,700** | **2,406,700** | **3,946,700** |

*Source*: CAER, 2008

The size of crushing and refining plants has changed over the past decade, and foreign investment and the increased involvement of the crushing industry have promoted the trend towards large plants. Biofuel plants can roughly be divided into three categories: small, medium and large scale (CESPA, 2007). Small scale plants, with a production capacity of up to 5,000m$^3$, account for only 0.3% of total production and meet their energy demand via self-supply. For the operators, disadvantages of this scale of production relate to operating costs (e.g. cost of meeting quality control, standardisation, pollution controls) and difficulties in obtaining feedstock. Medium scale plants, accounting for 8.1% of production, have a production capacity of between 5,000 to 33,000 m$^3$. They have reduced operating costs but may encounter difficulties in negotiating the price of inputs and carry a greater business risk due to the volatility of oil and grain markets. Large scale plants account for the vast majority of production (91.6%) and have a production capacity greater than 33,000m$^3$. In a competitive market, the main advantages of such plants arise from economies of scale, and the capacity to negotiate input prices. However, they incur high investment costs and risks may be high due to volatility in international markets.

## 4.5. ARGENTINE STAKEHOLDERS

As discussed previously, the current biofuel industry in Argentina is dominated by the vegetable oil refineries, who are interested in the large-scale production of soy-based biodiesel for the export market. Three Argentinean companies (Aceitera General Deheza (AGD), Molinos Rio de la Plata, and, Vicentín) and three multinational commodity companies (Bunge, Cargill and Dreyfus) account for 85% of the total Argentinean soy processing capacity (Lamers et al., 2008). Many of these companies have now invested substantially in the biodiesel industry (see table 2), many of them through joint ventures. In 2005, a joint venture was established between Vicentín and Glencore (a multinational commodity company). Both of these companies are already involved in the oilseed industry, owning crushing mills and refineries on the river Parana (Mathews and Goldsztein, 2009). In October 2007, a new soy processing unit (Renova) was started, with production expected to increase from 200,000 tonnes per year to 400,000 tonnes in 2009 (CAER, 2008). Similar ventures have been established between AGD and Bunge (Ecofuel: 200,000 tonnes per year), Dreyfus and the Hong Kong Noble Group. Joint venture is mutually beneficial to all partners because it minimises risk for Argentinean industries and provides foreign companies access to the Argentinean soy market (Mathews and Goldsztein, 2009).

Vegetable oil refineries inevitably have strong links to the agricultural sector, with many also providing agrochemicals, seed, and grain trading, financial and insurance services to farmers. AGD, Molinos, and Vicentín are also soy producers, while many also offer management services to farmers. In 2008, Molinos managed more than 70,000 hectares of Argentinean farmland (Molinos, 2009). Many of these companies are vertically integrated in the biodiesel value chain, giving them a hedge against price fluctuations; when the price of soy oil falls, these companies can produce more biodiesel and vice versa (Mathews and Goldsztein, 2009: 10). The contribution of the refineries to GDP, and their dominance in the agricultural sector, ensures these companies are able to exert a strong influence over the direction of biofuels development and policy.

Farmers, as providers of the feedstock and sometimes biofuel producers, are also important actors in the biodiesel industry. However, until recently the influence of most farmers has been limited as they are dispersed and divided by geography, scale of production, and ideology. Farmer leverage principally comes from membership of various networks that differ according to production method (e.g. AAPRESID), crop (e.g. ACSOJA, MAIZAR) and region (e.g. CREA). Large-scale producers that are integrated vertically in the supply chain, such as Vicentín and Molinos, will have far greater lobbying power than small and medium farmers. The recent protests over export taxes produced an unprecedented reaction from Argentina's farmers and succeeded in uniting factions that have traditionally been poles apart (e.g. Giarracca and Teubal, 2002). While it is unlikely that the unity created by the recent crisis will be maintained, it has shown that the farming sector is still capable of bringing the government to its knees.

The National Biofuels Commission is the Government body responsible for promoting the use of biofuels (both biodiesel and bioethanol) within Argentina. The Commission is comprised of representatives of each of the secretariats associated with national biofuel production: the Secretariat for Agriculture (SAGPyA), the Secretariat for Energy (SE), and the Secretariat for Environment and Sustainable Development (SAyDS). The Commission is responsible for coordinating national policy, promoting research into alternative feedstocks, supporting rural biofuel development, and encouraging investment in the sector (Leone, pers. comm.). However, the efficacy of this body is debated. It has been claimed that the Commission has been hindered by the diversity of interests amongst its representatives (e.g. Lamers et al., 2008), while others have claimed that the Commission has harmonised the actions taken by the various ministries (e.g. Mathews and Goldsztein, 2009).

There are also a number of public and private research organisations involved in the biofuel sector. The National Institute for Agricultural Technology (INTA) is a nationwide research institute providing technical assistance and support for farmers. INTA has a research programme dedicated to bioenergy that focuses on the development of other feedstocks, second generation biofuels, and research into the energy balance of existing feedstocks (INTA, 2008). Most universities are involved in agricultural research, and many also carry out research related to bioenergy including trials of jatropha and biofuel from waste projects. It should be stated that most research activities in Argentina are practically focused- there is little funding available and what is to be had is directed towards research with practical applications.

Within Argentina the third sector is largely absent and there are only a small handful of environmental NGOs; public awareness and concern for the environment in general is low. Understandably, the positions of these few NGOs towards biofuels are varied. *Fundación Vida Silvestre*, the Argentine arm of the World Wildlife Fund (WWF), supports the use of 'sustainable' biofuels and projects for *autoconsumo* (FVS, 2007). The *Fundación* is also a member of the Roundtable on Responsible Soy (RTRS), which was set up to define criteria for responsibly grown and processed soy and to promote best practice. The participation of the *Fundación* in this initiative has been criticised by other NGOs who argue that their involvement provides credibility to an initiative otherwise dominated by industry. The Group for Rural Reflection (*Grupo de Reflexion Rural,* GRR) stands at the opposite end of the extreme. A small NGO, comprised of activists dedicated to raising awareness of the environmental and social impacts of the agro-export model as practiced in Argentina, the group's position on biofuels is unflinching. Their view is that as long as the sector is dominated by multinationals, biofuels will do nothing but accelerate the consolidation of the agro-export model, a situation that is unacceptable to its members. GRR has had some success at increasing pressure on the government and other dominant stakeholders, and is raising awareness both in Argentina and abroad through the publication of reports, media coverage, and networking. In addition, GRR also works with numerous small networks and community groups across Argentina that are dedicated to fighting the expansion of the soy industry and raising awareness of the impacts of agrochemicals on the health of their communities (e.g. Joensen et al., 2007; GRR, 2009).

## 5. SUSTAINABILITY

### 5.1 LIFE CYCLE ASSESSMENT

A country-specific approach to Life Cycle Assessment (LCA) is vital when estimating the environmental impacts of bioenergy systems. Local conditions, such as agricultural practices, land use changes and transport infrastructures, will have a major impact on the environmental impacts of the system being modelled (Panichelli et al., 2009). To date, most LCA of soy-based biodiesel have been based on US data. While some studies have shown that the overall energy balance is negative, requiring 27% more fossil energy than conventional diesel (Pimentel and Patzek, 2005), other studies have claimed the opposite, that soybean biodiesel provides around 93% more energy than is required in its production (Hill et al., 2006). However, the application of US data to the Argentinean context is unlikely to be suitable and may lead to the misinterpretation of results or the approval of a feedstock that is in fact unsustainable due to its cultivation characteristics.

A recent study by Panichelli et al (2009) used an economic allocation approach to analyse the environmental performance of soy-based biodiesel produced in Argentina for export. The study found that "the global warming potential of biodiesel production in Argentina... is higher than the fossil reference and consequently is not a good choice to mitigate global warming" (p.150). The study found that the 'agricultural phase' accounted for 80% of global warming potential (GWP) in the Argentinean soy-biodiesel production system. The high GWP of feedstock production was primarily due to land use change i.e. deforestation and subsequent changes in carbon stocks.

In terms of energetics, however, Argentine soy-based biodiesel can be expected to have a decisive energetic advantage over Northern competitors; it has therefore been argued that it is strongly within Argentina's interests to commit resources into demonstrating this superior energy balance (Mathews and Goldsztein, 2008).

### 5.2. ENVIRONMENTAL IMPACTS

From an environmental perspective agricultural expansion, largely driven by demand for soy, has led to a number of negative impacts in Argentina.

## Argentinean soy based biodiesel: an introduction to production and impacts

Agricultural expansion has been the key driver of deforestation and habitat loss in Argentina since the late 19th century; in the past decade technological advances, combined with the high price of many agricultural products, have intensified this threat (MySA and UNEP, 2004; Magrin et al., 2005; Grau and Aide, 2008; Zak et al., 2008). Despite a wealth of information on deforestation rates in tropical areas, Zak et al (2004, 2008) express concern that far less research effort has been paid to deforestation in sub-tropical forests. The Chaco is a sub-tropical seasonally-dry forest, and is the second largest forested area in Latin America after the Amazon. In Argentina, the Chaco covers more than 22Mha (see Annex A3). However, the Argentine Chaco is being lost at an alarming rate. Between 1969 and 1999, the Chaco declined by 85%; this is equivalent to 2.2% per year, an exceptionally high rate of deforestation (Zak et al., 2004; 2008). The primary driver of this land use change has been agricultural expansion, whereby land is transformed from forests to soybean plantations and cattle ranches (ibid).

The extension of agriculture into previously forested areas will affect biodiversity, soil fertility, and lead to carbon losses from both soil and biomass. Production in arid areas is already causing desertification (Corregido, 2008), while changes in cropping patterns has led to flooding in others (Monti, 2007). Growing concern about the loss of Argentina's native forests led to the ratification of the *Ley de Bosques* (Law of the Forests) in November 2007. The law aims to 'establish minimum resources for the environmental protection and sustainable management of native forests and the ecological services that they provide'. However, as global demand for agricultural commodities, such as soy, increases so will the pressure on Argentina's forests and how successful this law will be in halting forest loss remains to be seen.

The Argentinean Association of Soil Science (*Asociación Argentina de la Ciencia del Suelo,* AACS, 2008) argues that 'sustainable' production of soy is possible dependent on the system of farming. It recommends the use of locally appropriate management practices that include crop rotations, conservation tillage, and the use of fertilisers. The production of soy in areas with fragile soils carries a greater risk of soil erosion and deterioration, as does cultivation in low lying areas that carry an increased risk of flooding. A 2008 report by the Department for the Environment and Sustainable Development (SAyDS, 2008) maintained that the economic success of agriculture had taken place at the expense of the soil. The report estimates that, in 2003 alone, the continuous production of soy led to the loss of 1 million tonnes of nitrogen and 227,000 tonnes of phosphorous. The cost of replacing these two nutrients was estimated at around US$910million. However, these inputs costs are almost never accounted for in farmers' estimates of net profits (Monti, 2008a), and are not reflected in the market price of soybean (Cavalett and Ortega, 2009).

Soil erosion is a concern for many stakeholders. Depending on management practices, slope, and local climate, the loss of soil can be as much as 19-30 tonnes per hectare annually. The adoption of no-till agriculture has helped to reduce soil erosion but the use of GM soy has enabled farmers to extend into areas with fragile soils or to cultivate year on year (SAyDS, 2008). No-till agriculture is more energetically efficient in terms of both labour and machinery, requiring only 35 litres of diesel per hectare whereas conventional tillage requires 60 litres per ha (Dalgaard, 2008). However, further research is needed on the carbon benefits associated with no-till agriculture, as well as on soil compaction. The use of water in agriculture, particularly in more arid areas, is also an under-researched issue.

The expansion of agriculture, the adoption of GM soy, and the use of no-till agriculture have all contributed to an increase in the use of agrochemicals, and in particular pesticides. For example, between 1996, when GM soy was first adopted, and 2007, the use of glyphosate increased from 14 million litres to more than 175 million litres (SAyDS, 2008). The herbicide glyphosate dominates agrochemical use, accounting for more than 70% of agrochemicals used in Argentina (Tuesca et al., 2007). The strong selection pressure exerted by the widespread use of glyphosate has led to the emergence of resistance in some weeds (Duke and Powles, 2008; Powles 2008), and in 2005, a glyphosate-resistant strain of the weed Johnson grass (*Sorghum halepense*) was confirmed in Argentina (Tuesca et al., 2007). Controlling these resistant weeds will require changes in management and the increased use of additional herbicides. It is estimated that, without strict controls, 25 million litres of herbicides, other than glyphosate, may be needed to control Johnson grass annually (Tuesca et al., 2007). Dalgaard et al (2008) note that imazethapyr, classified as 'slightly hazardous' by the World Health Organisation (WHO), and banned in Europe, has been used in combination with glyphosate in Argentina. In addition to contaminating water bodies and groundwater, the widespread application of agrochemicals can lead to changes in soil properties. However, there is little information available about the ecosystem impacts of agrochemicals in Argentina (SAyDS, 2008).

## 5.3. TRANSPORT

In Argentina, the vast majority of agricultural produce is transported by truck (91%), rail accounts for 8% and transportation by barge for 1% (Pozzolo et al., 2007). Rail infrastructure is poor and investment seems unlikely due to the strength of the trucking syndicates. Transport demand is seasonal, with periods of high demand coinciding with the harvest; this seasonality has disincentivised investment in the transport fleet and the average age of a truck is 20 years! The increased use of plastic silos to store agricultural produce after harvesting has reduced the peaks in transport demand; however, the disposal of these storage products is also associated with negative environmental impacts (see photos 1 and 2).

*Photo 1. A recycling centre for agricultural plastics, Santa Fe*

*Photo 2. Leachate from the recycling centre into a nearby stream, Santa Fe*

The transport fleet may be divided into short and long distance vehicles. Short distance, which transport produce less than 80km) are characterised by older vehicles, which travel less than 80km to move grain from the fields to agricultural stores. Long distance vehicles are generally more modern and are used to transport the grain to their final destinations, generally ports for export. The trucking industry is important to the economy, particularly as a source of employment. Pozzolo et al (2004) estimated that there are 155,000 businesses in the trucking industry of which only 2,000 are international companies. In 2004, the market value of the loads carried by trucks was US$ 4.4 million. The same study by Pozzolo et al (2004) investigated the loss of grains when transported by truck. They found that transport losses amounted to an average of 1.04% of the load per 320km; an estimated economic loss of US$18 million per annum. Unsurprisingly, grains lost during transportation were directly proportional to the age of the vehicle.

## 5.4. LAND OWNERSHIP

The economies of scale inherent to the agricultural production system, as well as the many economic crises that have plagued the country, have led to the concentration of land ownership. In the 1990s, State policies favoured larger producers, defining farms smaller than 200ha as 'uneconomic'. From 1992 to 2002, an estimated 60,000 small producers left agriculture (Giarracca and Teubal, 2002; Joensen et al, 2005). In the 2007 harvest, 60% of the soy harvest was produced by just 4% of farmers (Corregido, 2008). In addition, the high international price and profitability of soy has led to a rise in tenant farming and absentee landlords. Farmers who are unwilling or no longer able to take the production risk rent out their land to others-neighbours, contractors or investment trusts, who manage production from year to year. As a result, the value of land has increased five times in the past decade (Monti, 2008b), and in 2007 some 60% of farms were managed by tenants. The rise in tenancy farming has inevitably led to a loss of traditional and cultural knowledge which will be irreversible.

## 5.5. OTHER SOCIAL AND HEALTH IMPACTS

From a social perspective, the intensification of agriculture has led to a reduction in the rural labour force. Whereas small farms may create 1 job per 8 hectares, mechanised plantations may employ as few as 1 person per 200 hectares (Carvalho, 1999; Dros, 2004). While this may free up human capital for work in other economic sectors, in Argentina many small and medium farmers have not been successful in finding new areas of work. For many, livelihoods have been restricted to living off the rent from their lands, or to working for others. Furthermore, changes in land management have led to a rural exodus from the countryside and small rural towns to the cities in search of better economic opportunities. These changes in ownership and production are leading to the erosion of rural cultures and the loss of traditional knowledge and livelihoods. The spread of soy farming in Argentina will also have impacts on food sovereignty, as soybeans are cultivated at the expense of traditional livestock and crop production.

In both the developed and developing worlds, the widespread use of agrochemicals in agriculture has had public health impacts; in parts of the developing world, pesticide poisoning causes more fatalities than infectious diseases (Eddleston et al., 2002). Different populations may be exposed to agrochemicals in different ways, over different lengths of time, and to different extremes (WHO, 1990). In Argentina, there is increasing concern about impacts of the widespread use of agrochemicals, particularly pesticides, on the health of rural communities and ecosystems (GRR, 2009; Página 12, 2009a).

In agricultural production areas (see figure 1), crops are routinely sprayed with pesticides, from both the ground and the air, within a short distance of local communities (photo 3). People living in rural communities are therefore subject to regular, unintentional exposure to pesticides through their food, air and water supplies. Some individuals may also be directly exposed to agrochemicals due to employment in agriculture or the presence of chemical stores in their communities (WHO, 1990).

*Photo 3. Soy cultivation, Entre Ríos* [photo: Semino]

Chemical protectants, residual sprays and fumigants are also applied to the grains post-harvest in both the storehouses and transport containers (FAO, 1999). A further health threat is posed by the particulate matter (or dust) released by the storing, loading, unloading, drying and cleaning of grains (photo 4). Particulate matter, and the mites that may be present in them, are allergens and can produce respiratory and other ailments in vulnerable people (Dosman and Cockroft, 1989; Lerda et al., 2001). Finally, in Argentina the environmental laws regarding the storage and disposal of agrochemicals are often poorly enforced, and the potential for leakage represents a further hazard to human and ecosystem health (Semino et al., 2006).


*Photo 4. Soy grains being loaded for export*

The health impacts of long or constant exposure to low quantities of agrochemicals are chronic and, as a result, it can be very difficult to diagnose the causes (WHO, 1990). However, rural communities that live close to fields have documented high incidences of cancer, respiratory illnesses, and foetal abnormalities (GRR, 2009). However, there is a lack of official and empirical data on the impacts of pesticides on human health and the Argentinean health system records only acute poisoning. Therefore, most of the documentation regarding the long-term impacts of exposure to agrochemicals comes from health practitioners, the media, and affected communities and is largely anecdotal (Semino, 2008).

However, this situation may be set to change. In January 2009 a precedent was set when the *Madres de Ituzaingó* (Mothers of Ituzaingó) succeeded in winning an injunction that prevents farmers from using agrochemicals within 500 metres of their community. Ituzaingó is a suburb on the peripheries of Córdoba which is surrounded to the north, south and east by soy fields; of the 5,000 inhabitants, some 200 people have cancer, and incidences of allergies, skin irritation, foetal malformations, and neurological illnesses are also high. As a result of the ruling, the minimum distance for aerial spraying of agrochemicals will increase to 1,500 metres. The ruling applies to two agrochemicals, glyphosate and endosulphan, and may provide a precedent for hundreds of communities in similar situations (Página 12, 2009a). As a result of the ruling, and in response to increasing concern about the impacts of agrochemicals on rural communities, the Ministry of Health has established a committee to investigate the impacts of agrochemicals on local communities (Página 12, 2009b).

In addition, GRR, as part of its campaign 'Stop the Fumigations' (*Paren de Fumigar*), has further documented the impacts of agrochemicals on communities (GRR, 2009).

# 6. DISCUSSION

## 6.1. BIOFUELS: OPPORTUNITY OR THREAT FOR ARGENTINA?

As one would expect, Argentinean opinion varies as to whether biofuels are considered an opportunity or a threat for the nation. Those associated with agribusiness are keen to exploit the opportunities provided by biofuels, while NGOs (and some government departments) are concerned that biofuels represent an additional threat to an already unsustainable model of agricultural production.

Farmers' networks, such as AAPRESID and CREA, are excited by the opportunities that increased global demand for biofuels offers for their members. The Biofuels Law (26.093) had 'changed the vision and mission' of one network, and presented their members with real opportunities to add value to agricultural products. Amongst AAPRESID members, there had been initial interest in local production and use of biofuels (*autoconsumo*), but concern about the quality of the biodiesel produced and the impacts on engines had seen a shift in focus to supplying export markets. Both networks admitted that they had been taken by surprise by the speed and scale at which the biofuels export market had developed. Research into other feedstocks, particularly jatropha and castor, was considered vital in order to avoid competition with food production and to avoid using prime agricultural land for the production of biofuels. However, AAPRESID, the network for no-till producers, are concerned about the use of second generation biofuels; it argues that the use of agricultural residues, which are currently left on the soil, would lead to a loss of soil carbon.

For others, particularly NGOs (and some in government), the agro-export model means that the production of biofuels are inherently unsustainable. While it is acknowledged that for some of the farming community, increased demand for their products would represent economic opportunities, there is scepticism that such benefits would be evenly distributed. In the longer-term, biofuels based on the use of intensively cultivated soy would threaten the sustainability of production through impacts on soil fertility, soil erosion and intensive use of agrochemicals.

The Argentinean situation can in part be described as one in which economic actors are creating a de facto, commercially driven agri-fuels policy, in the absence of state leadership. Taking advantage of existing economic relationships, this policy consists of accelerated, large scale, mechanised soy-bean production for export to overseas markets. As such, European demand for biofuel, driven by regulation, is simply treated as an additional market for soy. Ironically, as we have outlined, European law intended for environmental protection is being directly implicated in adverse social and ecological changes (Semino, 2008).

The adverse environmental and social consequences of agricultural intensification may be seen as partly an outcome, albeit indirect, of the neo-liberal loosening of state institutions in Latin America, other examples of which include Renfrew's (2008) description of Uruguayan lead contamination and Guasch and Straub (2008) on political corruption in the water and transport sectors. That is, the State's protective policy role, with respect to its natural resources and weaker citizens, is not being adequately performed. Both policy and enforcement are in short supply. The situation contrasts with Aantjes' (2007) observations on agricultural sector policy networks involved in the lobbying of EC regulators during the development of EC legislation on biofuels. In Argentina, the primary role of the state in this context has been restricted to increasing taxes on agricultural exports for revenue purposes. Commercial actors have no need to negotiate complex policy networks, for the policy environment is sparse.

The Argentinean situation also differs from other emerging environmental political and economic contexts in which state agencies are involved in regulating new forms of natural appropriation or environmental technology. For example, Brand and Gorg (2003: 221) describe biodiversity politics, in which new intellectual property rights over the genetic material of flora and fauna is key, as oriented towards the: "creation of a stable political–institutional framework for its commercialization". In contrast, the Argentinean state does not appear to be actively supporting change in the agricultural sector, but rather seems content merely to profit from it. While Argentinean production of soy as an agri-fuel feedstock may be taking place in a relatively unsophisticated national policy context, the agricultural corporate sector has been undergoing a revolution focussed on production chain management, vertical integration and maximising economies of scale. Critical to this has been the deployment of Monsanto's "Roundup-Ready" Soy, tolerant to herbicide application.

Yet despite the enthusiasm from government and key stakeholders, particularly the petroleum and vegetable oil industries, the emergence of a biodiesel industry in Argentina is by no means guaranteed. Despite concerns about energy security, there is little domestic demand for biodiesel due to artificially low prices for conventional diesel. Environmental awareness is also low in Argentina. Scepticism and mistrust in government and industry amongst the public, following the economic collapse of 2001, might also hamper the development of a biodiesel industry if this were to increase the cost of fuel. In terms of establishing whether biofuels offer opportunity or threat for Argentina, it is clear that we must ask: 'for whom', and 'assuming what production conditions'? Currently, the benefits appear very much skewed towards the interests of the large landowners and their corporate partners, with biofuel feedstock production readily taking advantage of existing economic relationships.

## 6.2. IMPLICATIONS FOR SUSTAINABILITY CERTIFICATION

It is important to be aware of the scale of the GHG emissions problem that ill-sourced biofuels can cause. Table 3 uses default values given by the UK Department for Transport (DfT) for the carbon intensity of illustrative types of biodiesel types, and emission factors for associated land use change, to show worst case GHG savings with and without land use change (DfT, 2008). (DfT does not provide data for Jatropha). For comparison, averaged across the first five months of the RTFO, the GHG saving of biofuel supplied to the UK market (excluding indirect land use change) is reported as 44% (RFA, 2008b). However, as the previous land use is reported as 'unknown' for 41% (226.4ml), it is unclear how much confidence to place in that GHG saving. The RFA (pers. comm.) suggest that confidence can be placed in the value because their provisional reports show that a significant majority of fuel where previous land use is *known* comes from cropland (actually RFA Report 7, relating to the period April-November 2008, shows 44% of biofuel coming from cropland, though an additional 12% came from 'by-products', e.g. used cooking oil and tallow). Yet a supplier has a clear incentive to enter 'unknown' for feedstocks produced via adverse land use change (about which a supplier may not know), despite the RFA requiring a use of worst case emission factors values, and despite suppliers knowing that the RFA would take action if it were identified that a supplier was purposefully failing to report known data. While 'unknown' land use is a legitimate entry in RTFO returns, this problem will remain.

Moreover, a $CO_2$e payback period of a few years might be considered acceptable assuming a multi-decade plantation life, but the minimum period that Upham et al (in process) calculate for illustrative biodiesel feedstocks, using DfT's values and formula, is 25 years. Given the urgency of climate change, the possibility of even a worst case 25 year payback period is completely unacceptable, let alone the period of 5,500 years for Brazilian soy on deforested land, the 533 years for Argentinean soy grown on land converted from forest or 69 years on land converted from grassland.

**Table 3. GHG savings for illustrative biodiesel types under different land use change assumptions using DfT default values (Upham et al, in process)**

| Biodiesel Type | % GHG saving assuming land converted from cropland (a) | % GHG saving assuming land converted from forestland (b) | % GHG saving assuming land converted from grassland (c) | Payback time (years) (a) | Payback time (years) (b) | Payback time (years) (c) |
|---|---|---|---|---|---|---|
| Soy (Brazil) | 9 | -2550 | -699 | 0 | 5503 | 1523 |
| Soy (Argentina) | 44 | -1134 | -109 | 0 | 533 | 69 |
| Palm (Malaysia) | 48 | -135 | -12 | 0 | 77 | 25 |
| Palm (Indonesia) | 48 | -185 | -84 | 0 | 98 | 55 |
| Rapeseed (UK) | 36 | -569 | -123 | 0 | 335 | 88 |
| UCO (UK) | 85 | 85 | 85 | 0 | 0 | 0 |
| Jatropha | ? | ? | ? | 0 | ? | ? |

*Notes*: (1) payback time is the period for which a biofuel feedstock would need to be cultivated on a unit area of land to recoup the GHG emissions caused by clearing that area for its cultivation; (2) the feedstocks chosen above are likely candidates for UK biodiesel supply.

Even assuming that we can restrict the supply of biofuel to land not recently converted from old grassland or forestland, the problem of indirect land use change needs to be resolved *before* stimulating a substantially larger scale supply of biofuel. This will not be easy to achieve; indeed it may not even be achievable due to enforcement problems in states with large land areas, a lack of institutional capacity or willingness to enforce environmental protection laws, or simply a decision by a state to trade forest and grassland for crop production and associated (if sometimes short-lived) development benefits. The RTFO is unlikely to be alone in its inability to prevent indirect land use change – it is likely that no certification system will be able to ensure full reporting on this due to the causal processes involved being (by definition) indirect. Land use change will come about primarily where there is a price incentive and the investment capital and other resources available to make the change. It should be possible, with assumptions, to estimate the percentage of a land or commodity price attributable to biofuel demand. Similarly it should be possible to infer the area of the additional land area brought under cultivation for non-biofuel purposes as a result of displacement. Relating this to specific geographical areas and hence land types, however, is likely to be possible only on a regional, national or at best sub-national level. In other words, indirect land use change will be amenable to modelling at some level of resolution, but it is difficult to see how a certification approach can be used to prevent or identify it, as this would require tracing the linkage to a specific producer.

The problem of indirect land use change weakens the case for relying heavily on sustainability certification as proposed to date, as a primary environmental management tool for biofuel impact mitigation. It suggests that approaches are needed that anticipate and, in so far as is possible, avoid the problem. Strategic Environmental Assessment is intended for this purpose and has been rightly advocated by stakeholders for use in a biofuels context (e.g. JNCC, 2007). However, this still leaves the question of exactly how to avoid a level of adverse impacts of biofuel cultivation that will outweigh the benefits (while acknowledging that the latter is, to a significant degree, a value judgement). Although this requires further research, at this point it would appear that certification would be more reliable if it: (a) took the form of a stringent track and trace, bulk-commodity system that physically separated the certified product from uncertified product; plus (b) was legally backed by bi- or tri-lateral contracts between producer, refiner and retailer, with regular verification checks. This form of chain of custody would go beyond the mass-balance approach accepted under the RTFO (RFA, 2008b, p.24) and would be less susceptible to fraud. We do not have evidence for the latter, but, in countries with a history of institutional corruption and neglect, this is a reasonable concern.

There is a third, additional measure that can be taken to supplement sustainability certification and help to compensate for its constitutional inability to mitigate indirect land use change. That is, to incentivise only those feedstocks that have been pre-assessed as meeting particular criteria. While minimum GHG reduction performance is already imposed under the RTFO (DfT, 2008) and the need for future performance minima has been agreed to by the European Parliament (European Parliament, 2008), specific feedstocks are neither encouraged nor discouraged. Screening on a feedstock basis, by which is meant not just feedstocks per se but feedstock produced under particular conditions of positive environmental and social impact management (e.g. sugarcane conforming to the Better Sugarcane Initiative (Ferm, 2007)), would further reduce the risk of incentivising unwanted impacts. This need not be mandated at a policy level but could be enforced by, for example, large retailers.

## 7. CONCLUSIONS AND FURTHER WORK

This paper has barely begun to establish the nature of what critical UK observers might define as a ‘sustainable’ biofuel supply from Argentina. There is a vocal body of NGO opinion, promoted perhaps most strongly by Biofuelwatch, expressing the view that production of biofuel for export is undesirable and tantamount to expropriation of the rural poor by powerful western corporates. To date, our brief study of the Argentinean situation concurs that the current mode of soy production is indeed having adverse social and environmental impacts, yet it also begs many questions with wider implications.

Firstly, if the current development path for Argentinean biofuel production is undesirable, might a more positive social agrarian structure be encouraged by Northern biofuel policy? If so, how? Or should the mid-performing soy biodiesel (in terms of GHG savings) not be incentivised, even if produced in such a way as to benefit rural communities? A possibility that may raise the GHG performance of Argentinean soy is no-till cultivation, which we intend to examine further (but not experimentally - there is a need for scientific trials in this area).

Secondly, if certification cannot control indirect impacts and requires at least supplementing with measures such as those we have suggested (incentivising feedstocks highly selectively, using a track and trace approach to the chain of custody, physically separating certified product and bi- or tri-lateral contracts backed by regular verification checks), to what extent would such policies actually affect the production of poorer-performing feedstocks, given that these have alternative markets and that biofuel supply will likely always fall short of potential demand in circumstances of increased climate and energy security concerns?

These questions are not wholly amenable to qualitative investigation, for they require quantitative estimates of different types of demand. Qualitative investigation can, however, shed light on the nature of the modelling required – relevant variables and so on. With this in mind, focussing in particular on the no-till producers, in further work we aim to investigate in more detail the potential of Northern biofuel demand to counter some of the more adverse trends set in train by the TNCs, which currently monopolise seeds, herbicides and fertilisers in Argentina, as well as the export of grains. We will look more closely at alternative models of soy production, and at the views of a wider range of stakeholders.

Argentina's biofuel industry can serve as a lens through which to examine many of the issues and dilemmas posed by biofuels in general. It is already clear, however, that, relative to other renewables, biofuel production takes place in a uniquely complicated context, interfacing as it does with international agri-commodity markets that have their own associated positive and negative consequences. This complexity makes biofuels both a fascinating and demanding field for environmental and social assessment, and one in which multi-disciplinary research teams are ideally required.

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# ANNEXES

## A1. INTERNATIONAL DEMAND FOR SOY

Increasing international demand for soybeans and its derivatives has seen the total global area used for the production of soybean increase by more than 60%, between 1990 and 2005 (FAO, 2008). Demand for soy meal, a by-product of the soybean oil industry used in animal feed, has replaced soy oil as the principle driver of soybean production (FAO, 2007). The top four soybean producers (US, Brazil, Argentina and China) account for almost 90% of global production; by 2010, Brazil and Argentina combined are expected to surpass the US to become the world's leading producers (Dros, 2004). As a result of growing demand the price of soy has also increased making it ever more profitable to grow soy: in 2001, a tonne of soy was worth US$170-175, by 2008 the value had increased to US$480 per tonne (Jacques, 2008). In addition to the increased area under soybean cultivation, increased yields have contributed to the increase in global production; between 1960 and 2005, the average soy yield almost doubled. However, despite increased yields, the area currently under soy cultivation will soon be insufficient to meet demand, particularly as Asian markets expand and the biodiesel market develops.

## A2. NO-TILL AGRICULTURE AND GM SOY

Traditionally, crop production has required the use of tillage to bury crop residues, aerate the soil, remove weeds, mix in fertilisers, and prepare the earth for seeding. However, tillage leaves the soil vulnerable to water and wind erosion, can lead to soil compaction and increased sediment and agrochemical runoff. No till agriculture seeks to minimise soil disruption by leaving the crop residues as protective ground cover after harvest. By leaving the residues *in situ* they provide mulch that protects the soil from erosion; AAPRESID, the Argentinean farmers' association for no-till producers, estimates that soil erosion was reduced by 96% as a result of the adoption of no-till (2008).

In order to minimise soil disturbance, no-till agriculture requires the use of specialised seeding equipment to sow the fields. The use of no-till also provides additional environmental benefits, including increased water conservation and infiltration (which can increase yields and enable the production of alternative crops), limited runoff to waterways, increased soil biological activity, and cover and food for wildlife. There are also economic benefits from the use of no-till as fewer passes are required; in Argentina, the use of no-till has reduced fuel use by 66% (AAPRESID, 2008). Labour costs are also reduced by 30-50%. Proponents of no-till also cite the potential for carbon sequestration in soil organic matter, however recent studies have argued that the evidence is not compelling and that other reasons to promote no-till are stronger (Baker et al., 2007; Yang et al., 2008).

However, the transition to no-till is not straightforward as it can lead to the emergence of new pests and diseases, and therefore will require changes in management practices. One of the benefits of tilling is the removal of weeds and consequently, the adoption of no-till has led to higher dependence and use of chemical pesticides. Crop rotation is therefore recommended to reduce the incidence of pests and diseases, as production in monocultures will reduce the viability of no-till. Furthermore, no-till soils are generally cooler than conventionally tilled soils as the residues provide an insulating effect. As a result, crops may germinate more slowly, which reduces the use of early growth crops (Baker et al., 2007; Huggins and Reaganold, 2008). The transition to no-till also requires extension and support services for farmers. In Argentina, these services are provided by farmers' associations, such as AAPRESID, national research institutions, such as INTA, and universities.

*GM soy:* Prior to the introduction of GM soy, weeds led to lower yields, control was expensive and had only limited success (Tuesca et al., 2007). In 1997, Roundup Ready (RR) soy was commercially released in Argentina and by 2008 accounted for more than 98% of soy produced. RR soy has been genetically engineered to contain gene sequences that are resistant to glyphosate, the active ingredient in the herbicide, Roundup (Duke and Bowles, 2008). Glyphosate is a wide-spectrum herbicide that is used post-emergence; it is classified as 'relatively harmless' due to a lack of residual activity and rapid decomposition to organic components by soil microorganisms (Qaim and Traxler, 2005). Between 1994 and 2007, the use of glyphosate increased from 1 million litres to 180 million litres (Semino, 2008).

## A3. NATIVE HABITATS IN ARGENTINA

The 2007 consensus estimated that there were 31.4 million hectares of native forest remaining in Argentina, covering around 12% of the total land area (MSyA and UNEP, 2004). Plantation forests, principally eucalyptus and pine, cover around 1.1 million hectares. In 2005, the forestry sector accounted for 1.7% (SAGPyA, 2005). Argentina's native forests area can be divided into six ecoregions depending on the species assemblage, type of vegetation, soil characteristics and landform. Table 4 shows the extent of five of the six ecoregions; no figures were available for the Monte ecoregion.

**Table 4.** Area of native forests in Argentina, 2002

| Area | Selva Misionera | Selva Tucumano Boliviana | Bosque Andino Patagónico | Parque Chaqueño | Monte | Espinal | Total |
|---|---|---|---|---|---|---|---|
| Forested area * (ha) | 914,823 | 397,483 | 1,985,495 | 22,040,637 | - | 2,844,066 | 28,182,504 |
| Rural forests ‡ (ha) | 538,558 | 29,352 | - | 1,327,347 | - | 168,681 | 2,063,938 |
| Total forest cover (ha) | 1,453,381 | 426,835 | 1,985,495 | 23,367,984 | - | 3,012,747 | 30,246,442 |

*Source:* MSyA and UNEP (2004). *Land greater than 10ha with more than 20% canopy cover; trees grow to more than 7m when mature. ‡Remnants of natural forests of less than 1,000 ha within an agricultural landscape.

### SELVA MISIONERA (PARANAENSE FOREST)

The Selva Misionera is a subtropical forest. In Argentina it is principally located in the province of Misiones, extending into Paraguay and Brazil. It is home to almost 40% of Argentina's biodiversity, and produces more than 70% of the country's timber (Eibl and Fernandez, 2005). In 1850, the forest covered virtually the entire province, or an area of 2.7 Mha. By the 1970s, government incentives for commercial plantations of exotic species (pine and eucalyptus) and cash crops (tea, yerba mate, and tobacco), as well as increased access from infrastructure development, had reduced forest cover by more than 50% (ibid); this exploitation has continued unabated. The 2007 inventory revealed that there are less than 1 Mha of Paranaense forest remaining (SAGPyA, 2007). Agricultural expansion, the extraction of high value tree species, and unsustainable forest management continue to threaten this valuable forest (Greenpeace, 2008).

## SELVA TUCUMANO BOLIVIANA (YUNGAS)

The Yungas cloudforest extends from the border with Bolivia to the province of Catamarca. The Yungas occupies a range of terrains and elevations making it extremely diverse and rich in biodiversity, with around 120 mammal species, including the emblematic tapir and jaguar, and more than 200 tree species. At lower altitudes, the principal threats are conversion to agriculture for cash crops, such as sugar cane and, more recently, soya. Selective felling and overgrazing are the key threats at higher elevations. In 2002, an estimated 3.7 Mha remain, less than half of the original forest cover (MSyA and UNEP, 2004).

## PARQUE CHAQUEÑO (CHACO)

The Chaco represents the second largest forested area in Latin America after the Amazon. In Argentina, it covers more than 22Mha and can be divided into four subregions, although savannahs and thorn forests dominate. During the early 20$^{th}$ century, population growth, expansion of the rail network and consolidation of the agroexport model contributed to the loss of this forest. To demonstrate, in the Chaco ecoregion in 1888, croplands covered 2.46 Mha but by 1970 more than 27 Mha were cultivated (Greenpeace, 2008). Today, the Chaco is threatened by the extension of the agricultural frontier, principally due to the expansion of soy. Fire and selective felling are also leading to forest degradation. A further threat is that of desertification due to the lack of soil conservation measures.

## EL ESPINAL

The Espinal is a dry, thorny deciduous forest, located to south of the Chaco and surrounding the central Pampas. Many of the species found in the Espinal are found elsewhere, although the caldén (*Prosopis caldenia*), is one of the few species endemic to this ecoregion. Due to its proximity to the Pampas, the main agricultural zone in Argentina, the principal threat to the Espinal is agricultural expansion. Modern irrigation systems have also made this arid ecoregion apt for agriculture. Fire and timber extraction are also important threats to this woodland. In 2002, the Espinal covered around 2.5Mha.

## BOSQUE ANDINO PATAGÓNICO (ANDEAN PATAGONIAN FOREST)

The Andean Patagonian forest extends along the Andean Cordillera, a distance of approximately 3,000km. At its widest it extends no more than 30km. To the north, this forest type is dominated by deciduous trees while to the south evergreens dominate. This ecoregion is one of the most degraded in Argentina due to cattle farming and unsustainable forest management; however, a large percentage is protected. Fire and population growth are also key threats to this ecoregion, of which an estimated 1.9Mha remain.

## EL MONTE

The Argentinean Monte is a dry forest biome, characterised by a temperate, arid climate and low rainfall (80 – 250mm per year). It extends across different elevations from coastal zones to more than 2,800m. The Monte is dominated by scrublands and xerophilous open woodland. Several species of fauna and flora are endemic to this ecoregion. Overgrazing, land clearance for agriculture, mining and oil exploration, and selective felling all represent serious threats to this woodland. In addition, human activities have accelerated desertification processes in this already arid zone.

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