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Environmental and Social Impacts of Soy Production under Globalized Conditions – Examples from Brazil –

Julia Bundesmann

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First corrector: Prof. Dr. Rainer Buchwald
Second corrector: Prof. Dr. Catherine Legrand



Zusammenfassung / Abstract

Als Kulturpflanze wurde Soja schon vor Jahrtausenden in Asien angebaut. Zum sogenannten „cash crop“ (exportorientierte Feldfrucht) wurde sie unter Anderem erst durch marktwirtschaftliche Entwicklungen auf dem Weltmarkt seit 1960, eine erhöhte Nachfrage nach Futtermitteln für die wachsende Fleischindustrie und den steigenden Bedarf an alternativen Brennstoffen anstelle der sich erschöpfenden fossilen Brennstoffe. Im Laufe dieser Entwicklungen wurde Brasilien neben den USA zum zweitgrößten Sojaproduzenten und Exporteur. Die verheerenden ökologischen und sozialen Auswirkungen von Sojaanbau und -produktion, die hier am Beispiel Brasilien vorgestellt werden, werfen die Frage nach den Gründen und Hintergründen dieser Entwicklung auf. Soja ist zu einem wichtigen Rohstoff geworden und dient heutzutage als Sojamehl für Viehfutter, als Sojaöl für Biodiesel und ist in unzähligen Produkten unseres täglichen Lebens und in Nahrungsmitteln enthalten.

Ökologische Folgen sind der Verlust von einmaligen Ökosystemen wie der brazilianische Regenwald und Savanna durch die Rodungen für den Sojaanbau und der Rückgang an Biodiversität durch Monokulturen und transgene Pflanzen. Hinzu kommen Bodenerosion und Wasserkontaminierung durch Intensivierung und Machanisierung der Landwirtschaft und Pestizideinsatz, der zu verbreiteten Resistenzen führt, sowie Folgeschäden durch den Ausbau von Transport- und Wasserwegen.

Die ökologischen Auswirkungen stehen zusätzlich in enger Wechselwirkung mit sozialen und ökonomischen Problemen, die durch den Anbau und die Produktion von Soja auftreten. Besonders in Brasilien sind die Landbesitzrechte von Kleinbauern sowie ländlicher und indigener Bevölkerung weder eindeutig geklärt noch geschützt. Dies führt dazu, dass sie durch die sich ausbreitenden Sojaplantagen vertrieben werden, Land und Lebensgrundlage verlieren und kaum Arbeit auf den stark mechanisierten Sojafarmen oder in Agrifirmen finden. Die Sojaproduktion wird zu großen Teilen von multinationalen Firmen (MNCs) betrieben, die von Saatgut über Dünger und Pestizide bis hin zu Maschinen und Anlagen alles anbieten und kontrollieren. Durch Saatgut-Dünger-Pakete mit transgenem Saatgut wie der *Roundup Ready* Sojabohne von *Monsanto* werden Sojabauern in Abhängigkeitsverhältnisse gezwungen.

Die Regierungen in den USA, Brasilien und in der EU unterstützen durch Subventionen die wirtschaftliche Entwicklung von Soja. Die Einnahmen der Staaten durch die Exportsteuer wiederum kommen weder den brasilianischen Bauern noch der Entwicklung ländlicher Gebiete und deren Bevölkerung, noch führt sie zu nachhaltiger Landwirtschaft oder stellt eine Lösung des Hungerproblems dar. Diese Ungleichheit spitzt sich durch die Steigerung des Sojaanbaus für Biokraftstoffe weiter zu.

Ziel dieser Arbeit ist es, die Zusammenhänge des globalen Sojakomplexes mit Schwerpunkt auf Brasilien und die dadurch entstehenden ökologischen und sozialen Probleme aufzuzeigen. Außerdem sollen verschiedene Lösungsansätze vorgestellt werden zu denen die Zertifizierung, ökologische Anbaumethoden sowie nachhaltige Marktentwicklungen gehören. Zertifizierungen vom *Round Table for Responsible Soy* (RTRS) mit Akteuren aus Industrie und NGOs (Nichtregierungsorganisationen) oder das Fairtrade-Siegel von FLO (*Fair Trade Labelling Organization*) zielen auf ökologisch nachhaltigen Anbau und sozial fairen Handel ab. Der Unterschied ist die Schwerpunktsetzung auf groß- beziehungsweise kleinformatige Produktion und Abnehmerkunden. Soja auf Nachhaltigkeit und fairen Handel zu zertifizieren und damit den negativen Auswirkungen entgegenzuwirken, sehe

ich unter den momentanen Bedingungen in der die Sojaproduktion als industrialisierte Landwirtschaft von marktwirtschaftlich orientierten Großunternehmen und Exportverträgen zwischen Staaten diktiert wird, als Lösung nicht möglich und erst recht nicht als ausreichend an.

Staatliche Kontrollen und gesetzliche Auflagen sind nötig um das Foranschreiten Rodungen für den Sojaanbau zu stoppen. Brasiliens Regierung sollte Privatisierungen der Sojaindustrie duch ausländische Firmen besser kontrollieren um den Binnenmarkt zu fördern und sich damit weniger abhängig vom Exportmarkt zu machen. Gleichzeitig kann so die regionale Landwirtschaft wieder gestärkt und Arbeitsplätze gesichert werden und zur Entwicklung ländlicher Gebiete auch im Hinblick auf Bildung und Gesundheitsstandard positiv beeinflusst werden. Dezentrale Einrichtungen können die Bauern und ländliche Bevölkerung viel gezielter über ökologisch-nachhaltige Anbaumethoden und mögliche Gesundheitschäden durch Pestizideinsatz aufklären und gesetzliche Auflagen kontrollieren.

Schonenden Bodenbearbeitung, der Verzicht auf den Einsatz von chemischen Pestiziden und Düngern sowie auf gentechnisch verändertes Saatgut sind einige Ansätze um den Anbau ökologisch nachhaltiger und schonender für Boden und Wasser zu gestalten.

Langfristig ist neben diesen Lösungsansätzen ein Umdenken im Konsumverhalten und bei Regierungsentscheidungen zu Gunsten der Bauern und des Erhalts der Natur in Brasilien am nachhaltigsten.

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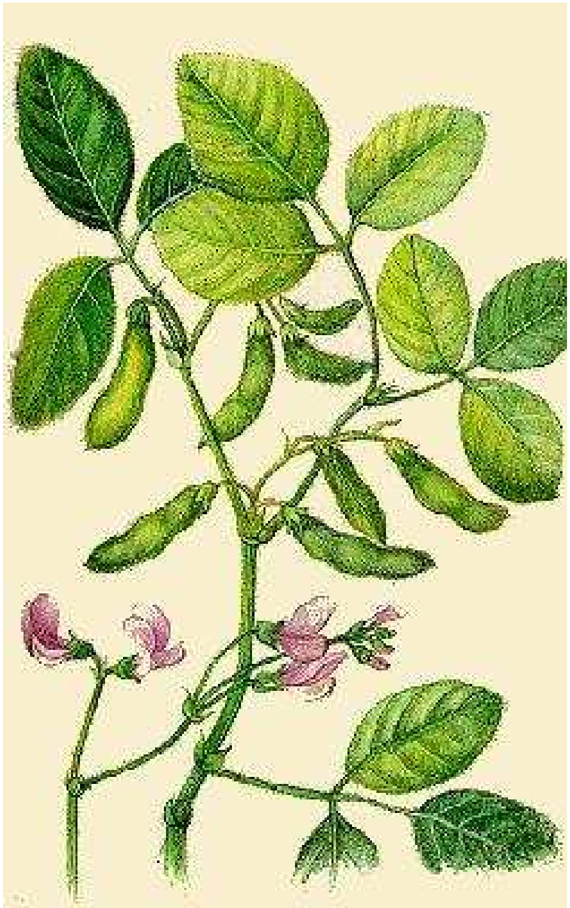

Figure 1: The soy plant

1 Introduction

Soy – a blessing for the green energy revolution and a cheap, protein-rich animal food, and solution for world hunger or a curse to biodiversity, rain forests, small farmers' economy, and the world climate? How can such a small bean have such great impact on a global scale? The development of the soy boom with all its environmental, social, and economic aspects is a great example for globalization.

Soy has its origin in Asia where it was cultivated for food. Today, soy is mostly used as meal or oil, as feed for livestock or for biofuel production. How did this happen and what are the consequences? These are the questions I want to answer in this thesis and for this I will focus on Latin America, more precisely Brazil. With soy as the major export commodity and Brazil's rapid adaptation to the world market as one of the leading soy producers, impacts on nature and people have been dramatic. With the Amazon rainforest, cerrado savanna, Atlantic rainforest, and many large waterways that reach across South Amercia Brazil holds some of the biggest and most diverse bioms . Moreover, soy production in Brazil has caused social inequity due to large agribusinesses and unilateral government interest. Therefore, Brazil is a good example of the devastating impacts of soy production.

First (in chapter 3), I want to introduce the soy plant with its distinct properties of high protein and oil value. Then, in the second part (in chapter 4), I will show where and how soy is cultivated and produced, including the use of pesticides and transgenic seeds, and what soy is used for. Thirdly (in chapter 5), I will highlight the vast environmental impacts of soy production which cannot be overlooked when rainforests make way for huge soy mono-cultures (see Figure 2, Figure 3, Figure 4) and the biological value of land (soil, water, biodiversity) is degraded. Tightly connected are the negative social aspects such as land rights, working conditions, dependencies and inequity of the soy complex. The economic and political role of the soybean helps to understand the reasons for its industrialization. In the fourth part (in chapter 6) I will shortly explain the development of the soy market, the role of biofuels in it. Also, I will show the power of globalized markets and multinational corporations (MNCs). However, since this is not the emphasis of the thesis, I cannot go into economic or political detail. Yet, financial subsidies, governmental policies, and certificates do in turn influence environmental and social factors and can therefore not be denied. Finally (in chapter 7), I want to look at the certification scheme of the *Round Table on Responsible Soy* (RTRS) as well as the criteria for the *Transfair* fair trade label. The two best practice examples are also based on certificates. One emphasizes on establishing a communication network between soy actors of Brazil and Germany, while the other is a practical approach to small scale and fair trade production. Since certification alone cannot ensure social and ecological sustainability, conservation agriculture methods and change in policies will be suggested.

Still, I would like to question the value of sustainable soy under the given conditions where large global players disrespect environment and people for financial benefit.

Figure 2: Deforested area in Mato Grosso

Figure 3: Soy field in Brazil

Figure 4: Soy fields in Mato Grosso, 2008

2 Methods

The information for this research was obtained from books from the university library Oldenburg, from scientific papers found in the online database *Web of Science* of the university library and numerous internet sources. If files were not available, I contacted the author directly and was lucky to have them send me the article. Most current information was mainly found in the internet since some of the books were quite outdated. Most scientific papers were published in *The Journal of Peasant Studies* or other journals related to environmental conservation and agriculture. Websites of international NGOs (Non-Governmental-Organizations) like *World Watch*, *Greenpeace* or *Transfair*, Brazilian agrarian institutes like *Embrapa*, and American soy research programs (for example from the Iowa State University) as well as databases from the FAO (*Food and Agriculture Organization*),*Earth trends* and from the *World Bank* were good sources for up-to-date information.

3 Botany of the Soy Plant

The soy plant (*Glycine max* (L.) Merr.) belongs to the family of the Fabaceae and is an annual crop with high agricultural value. Its origin is in East Asia, more precisely in China, where it has been known since 2800 B.C. [**?**] and used as food and animal feed.

In its appearance all parts of the plant are pubescent and the leaves trifoliate. The small flowers are light purple to yellow (see Figure 5a) and bloom in grapes from bottom to top of the plant. After self-pollination fruits in form of pods with two to five seeds ripen in the axillas. The leaves fall off during the fruit ripening (see Figure 5b), which is an advantage for harvesting. The plants grow to be between 30 cm to 2 m high. The flowering periods depend on temperature as well as light hours and start when temperatures reach $20 - 30\,^{\circ}$C. The vegetation period takes about 4 to 5 months depending on the regional climate. Soy can grow in almost all climates and latitudes and does not require special soil composition. Frost before flowering and too wet soil conditions can destroy a year's soy harvest. The seeds are rich in protein (40%), fats (20%), and carbohydrates (35%) which is why soy is such a valuable and multifunctional crop [Bertrand 1984, **?**, Reh and Espig 1984].

(a) Full flowering

(b) Full maturity

Figure 5: The soy plant in two reproductive stages

Because of its protein-rich properties soy is a good food source for animals and humans. Soy also contains more essential amino acids like lysin, threonine, tryptophan, and nutrients than many other foods [Clay 2004, Lanje 2005].

Since soy belongs to the legumes, another important property is its ability to fix nitrogen. Special rhizobia (root bacteria) fix the nitrogen from the air and store it in the soil making it available for the plant and fertilizing the soil. This symbiosis is very important for the soy plants and must be considered when soy is cultivated. When soy is planted for the first time, either the bacteria must be applied directly to the soil or the seeds must be covered, the latter is the most common method [Bertrand 1984]. This trait makes soy a valuable preceding crop that enriches the soil with nitrogen and saves fertilizer later on.

4 Soy Cultivation and Production

4.1 Countries Involved

The major producers of soybeans are the USA, Brazil, Argentina and China sorted by production share followed by India, Paraguay, Canada, Bolivia and Indonesia with a minor share [Clay 2004].In the US most of the midwestern states, also known as the corn belt, have intensive agriculture and many grow soy in rotation with corn. In the southeastern states soy has replaced cotton and wheat. In Brazil industrialized soy agriculture started in the southeastern states and has consistently spread northwards. Important soy producing states (total of 17 Brazilian states are involved) are Rio Grande do Sul, Paraná, São Paulo, Mato Grosso do Sul, and Mato Grosso, Minas Gerais, Goiás as traditional soy states and Pará and Amazonas in the north being more and more occupied by the emerging soy frontier(see Figure 6).

Figure 6: The Brazilian states

Since soy is mainly an export commodity, producing countries are also major exporters, with the USA and Brazil up front followed by Argentina, Paraguay, The Netherlands, Canada and Bolivia. Interestingly, China is the largest importer of soy with 60% (51 mio tons) of the global soy import, followed by the EU with 17 mio tons in 2010/2011 [USDA 2010], Japan, Mexico, South Korea, Thailand, and Indonesia with much smaller amounts [Clay 2004]. China grows its own soy mainly for human consumption but the higher demand for other uses is met by the growing Brazilian and Argentinian exports. Yet, the biggest exporter is still the USA followed by Brazil.

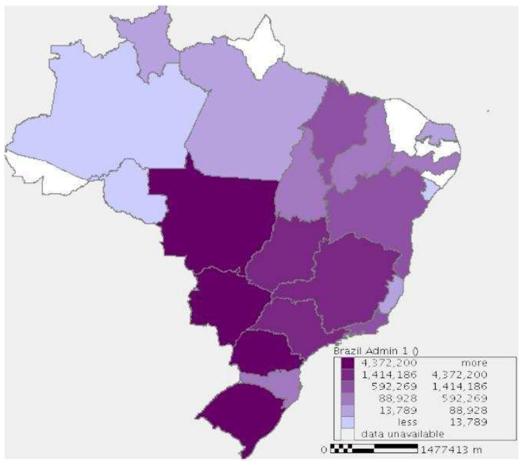

Figure 7: Soybean production in Brazil in metric tonnes

In the growing season of 2009/2010 about 260 mio tons of soy were produced on 102 mio hectare world-wide. Out of these, alone 69 mio tons were produced in Brazil on a total area of 24 mio ha [Embrapa.br](an area a little smaller than Italy)(see Figure 7). In 2010/2011 the soybean production is estimated to reach 250 million tons in the three largest soy producing countries (USA, Brazil, and Argentina) which results in 170 million tons of soybean meal and 40 million tons of soy oil. The average export price for US soybeans in 2010 was 400 $ per ton [USDA 2010].

4.2 Cultivation

Figure 8: Machines harvesting soy in Brazil

Figure 9: Aerial pesticide spraying

For industrialized soy cultivation beans are planted in rows about 1 meter apart with each plant about 5 cm apart from the next. Planting as well as the process of soil preparation, cultivation, chemical application and harvesting are mechanized.

Growing seasons strongly depend on light hours and temperature. In the USA the growing season is shorter than in Brazil with 95-100 days until maturity instead of 115-145 days respectively. The longer growing season and tropical climate in Brazil is good for cultivation and produces larger plants. But the tropical climate is also problematic because it enhances fungi growth and seeds are threatened by mildew and mold. The use of Fungicide and herbicide adds to production expenses and makes up about 20% of the overall production cost [Clay 2004, Lanje 2005]. Pesticides are applied either directly to the soil during the seeding process or sprayed (once or several times) with machines or airplanes onto the plants (see Figure 9). Pesticides include herbicides, fungicides, and insecticides. The quantity and type of pesticides used depends on the region's climate, soil conditions and pests the plantation has been exposed to. As further described in 4.4 pesticides are adapted and matched to the kind of seeds they are used with which is supposed to reduce pesticide and fertilizer use.

Soy can easily be grown as a rotation crop with corn or cotton and utilized to enrich nitrogen in the soil. To achieve a higher content of organic material in the soil in some areas rice is planted before the normal crop rotation of corn and soy. After mono-crop soy cultivation the exhausted soil is then used in rotation with cattle ranching for a few years. In the Brazilian cerrado (savanna) the soil has been treated with lime for many years to make it suitable for crop cultivation. Lime counteracts the soil acidity and neutralized soil makes the nutrients more easily available to the crops [Clay 2004].

To reduce soil preparation cost and conserve soil quality, no tillage (no-till) or conservation tillage methods in combination with pesticide use have been applied where the soil is not disrupted (plowed). An additional conservation method is direct planting where seeds are planted during the process of harvesting under the left-over plant material. The plant residues are left on the field after harvesting to cover and protect the soil. With the no-till method higher yields can be achieved especially with genetically modified soy in combination with glyphosate herbicide (which is questionable, refer to 4.4). The killed weeds can serve as mulch to protect the soil, hold water, and build up organic matter, which is an advantage of the combined herbicide use and no-till method.

Soy is harvested once a year. In Brazil from February until May, while in the USA the harvesting season is during September and October [Bertrand 1984]. Harvesting and threshing is combined in one process and happens directly on the field with two consecutive machines in big fleets (see Figure 8). First, the stalks are cut and the pods separated. Later, the beans are transferred onto trucks waiting next to the field and transported to big storage depots. From there railway lines lead to warehouses and processors or to other transportation fleets. In the depot beans need to be cleaned from left-over plant material, stones and dirt, and are dried. The price farmers get is per dry weight [Clay 2004].

4.3 Processing and Uses: Beans, Oil, Meal

Processing of the harvested soybeans (see Figure 10) is not done on the farms but at big crop processors or mills. In this process called crushing, the beans are first ground and then pressed to separate the meal and the oil. This yields about 19% oil and 74% meal which contains about 35% protein [Clay 2004]. Afterwards, each base product is processed further. Since soy oil and soybean meal are processed together in the first step, their market prices are highly correlated and influence each other.

One use is the raw soybean itself which is edible and mainly used for food products in China and Japan. Dried beans must be soaked and cooked for a long time before consumption in order to break down the proteins. Most soybeans are processed to become soybean meal and soy oil. These two "basic materials" take on many forms in numerous products that we would not have thought to contain soy.

Soy oil is used in many food production chains to substitute or contribute to cheap vegetable oil used in baking fats, margarine, pastry, etc. where it is indicated as lecithin. Dried soy oil is widely used for technical and industrial purposes as an emulsifying agent (glycerin), in the pharma industry, in paints (ranging from printer ink to fabric dye), pesticides, insulating material, plastics, soaps and other cosmetics. Soy oil is also used as biodiesel to add to renewable fuel alternatives (more in 6.2).

The protein rich soybean meal is used as cheap and nutritious animal feed mainly for poultry and pigs to replace fish meal. Cornmeal is cheaper but not as nutritious [Clay 2004], therefore, soybean and cornmeal are often mixed. Foodstuff like bread products, noodles and canned food also contain soy protein. It is also widely used in the biochemical industry for fertilizers, pharmaceutical products, as synthetic fibers, glues and foaming materials to name just a few [Reh and Espig 1984, Bertrand 1984].

Figure 10: Harvested soybeans

The production companies specialize in animal feed or food components and milling, transportation and processing are controlled by just a few big companies. These sometimes have direct influence on soy cultivation since they also sell the seeds, agrochemicals and fertilizers and thus control a large part of the whole production process [Bertrand 1984](read more in 6.3).

4.4 Pesticides and Transgenic Soy

The issue of genetically modified organisms (GMOs) has been widely discussed. Since 52% of the world's transgenic area is soybean and the ban against GM soy in Brazil has ended in 2003 [Lanje 2005], this issue needs to be covered here as well. With the goal to achieve high yields and not lose harvests to weeds or insects, crops' DNA has been engineered to be resistant either directly to a pest with the built-in trait or indirectly resistant to the insecticides, fungicides, and herbicides applied to the field.

The so-called Bt-crops have a trait from the soil organism *Bacillus thuringiensis*(Bt-) which works as a deadly toxin against certain insects trying to eat the crop. Hopes are that the chemical costs can be reduced but of course prices for designed seeds are higher. Another factor that cannot be disregarded is the development of resistances of plants, insects and also pathogens towards more and more kinds of pesticides. Since toxins are being expelled all the time, pests can develop resistances due to constant exposure. To counteract that, areas with normal plants serving as refugia have to be planted next to the Bt-crop fields. This approach should prevent pests from developing resistances since they are not exposed to the toxin at all times. But farmers either do not want to abandon valuable land to refugia or do not give them enough space to have positive effects for the resistance problem. Another issue that arises with the refugia is that non-Bt-crops in the refugia areas can be cross-contaminated by the Bt-crops through wind, insects or birds which then gives them a competitive advantage and the ecological effects cannot be controlled [Halweil 1999]. Cross-contamination belongs to the worst-case scenarios feared by GMO critics.

The other option is to make the crops' DNA resistant to the pesticides. These HRCs (herbicide-resistant crops) are usually engineered and sold by biotech companies in packages containing the seeds and the compatible herbicide. One well-known example is *Monsanto's Round Up Ready* Soy developed in the 1990s (and was first authorized in the US 1994 [Greenpeace 2000]) which tolerates the glyphosate herbicide *Round Up* for which *Monsanto* holds a monopoly patent. Glyphosate is the most commonly used herbicide since it covers many different pests and kills most weeds. But glyphosate also has negative effects on beneficial soil fungi and nitrogen fixing bacteria so that a larger amount of fertilizer needa to be applied [Fearnside 2001, Clay 2004].

Since glysophate was first introduced the concentrations applied on the fields have constantly been increased due to the resistances that have developed [Tomei et al. 2010]. HRCs require little or no tillage which reduces the cost of plowing and conserves the topsoil. But these benefits are only short-lived since soil compaction causes soil erosion and plants and insects adapt to the pesticides as well. These resistances force farmers into a pesticide treadmill demanding ever increasing amounts of even more highly toxic chemicals and making them dependent on the seed contracts with agricompanies such as

Monsanto, Aventis, Novartis, DuPont, Pioneer, and *Cargill* who along with a few others make up the global seed market. The firms hold patents on the seeds and farmers are not allowed to save seeds for the next year or breed themselves but need to purchase new seeds every year. Companies are working on seed sterility mechanisms to prevent harvested seeds from germinating again. In this way farmers are dependent on the firms who supply the seeds and control the market. Gene ownership is essential for the agriindustry since it allows one firm to hold monopoly rights (patents) on transgenic soy traits who can then set the price and erode the economic sustainability.

The industry for GM seeds and soy products focuses on just a few products for a large, secure market which requires capital-intensive production. Small farmers with non-mechanized cultivation processes cannot join the transgenic soy production and its supposed advantages. One argument often held by pro-GM exponents is that the higher yields of transgenic crops can solve the problem of world hunger. But as just stated, the soy is only produced for export and not for local consumption [Halweil 1999] and it is not possible for small farmers to grow GM soy for self-supply. There is no doubt that GMOs have already led to a dramatic loss in biodiversity. There is little knowledge about long-term effects of GMOs since data on and monitoring of the crop design and uses are not transparent. Studies have shown health problems related to glyphosate such as reproductive disorders, tumors, and embryo misdevelopment in mammals(Cox 1998 in [Clay 2004]). In 2000 Greenpeace informed about newly found genetic material in the *Roundup Ready* soy which has neither been reported nor authorized. Before GMOs are allowed on the market, information about their genetic material and its functions must be presented and then authorized by each country where it is used. But GM soy has been cultivated without authorization in Brazil long before the ban against transgenic soy ended. If additional and non-identified DNA strains in any designed seeds are found the seeds need to be withdrawn from the market and import stops imposed for example by the EU who have strict guidelines about GMO imports. Nothing of this happened with *Roundup Ready* and questions about the unidentified genes and illegal seeds have not been answered yet by *Monsanto* [Greenpeace 2000].

5 Ecological and Social Impacts

"Growing worldwide demand for soy is shaping South America's agricultural output and development policy" [Steward 2007]. Agriculture in Brazil rapidly industrialized to large-scale soy production and cattle ranching during the 1960s to 1980s due to governmental projects that sought to drive rural area development and is still proceeding today. These agricultural reforms supported the establishment of large farms in the south and mid-east area. The major environmental impacts are the conversion of natural habitat through deforestation of the Atlantic rain forest (Mata Atlantica) and clearing of the cerrado (savanna) which results in the loss of unique biodiversity. Deforestation and mechanized agricultural land use cause soil erosion and degradation accompanied by water pollution through the use of agrochemicals. In addition to that, genetically modified seeds bear risks of environmental impacts not yet predictable [Clay 2004].

The ecological and social issues caused by these scenarios are tightly connected. Small farmers without legal land rights are expelled from their land and move further north to the Amazon frontier to clear more forest. Health and working conditions are poor. I will go into detail on these issues individually in the following sections.

5.1 Deforestation and Loss of Biodiversity

The rapid growth of the soy plantations in Brazil resulted in clearing and burning of large parts of the Atlantic rainforest in the south-east of the country as well as the cerrados (scrub savanna) on the mid-eastern plateau. The emerging soy frontier now also threatens the Amazon rainforest in the north (see Figure 12). 70% of Brazilian deforestation is connected to soy [Lanje 2005] and not only primary forest is cleared. Also secondary forests that developed in succession of cattle ranching are cleared because they are not considered valuable and are not under protection. Different valuation of first and secondary forest for soy production are discussed in Stewards paper of 2006. There criticism is raised that government and agribusinesses define only two categories of forest (primary and secondary) in the legal maps; secondary forest is evaluated as no-forest and is therefore approved for soy cultivation. In contrast, *Embrapa* (Brazilian Ministry for Agriculture Research)defines at least eight defined forest classes with distinct protection levels.

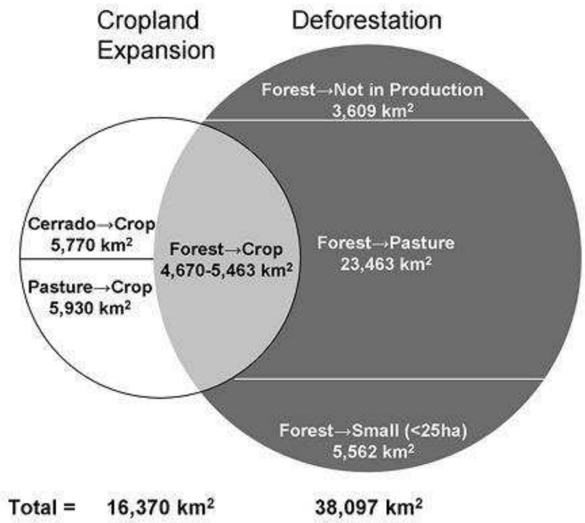

Figure 11: Relationship between cropland expansion and deforestation in Mato Grosso, Brazil, during 2001–2004

"The arc of deforestation along the southern and eastern extend of the Brazilian Amazon is the most active land-used frontier in the world" [Morton et al. 2006]. The state of Mato Grosso has experienced the most rapid expansion of cropland and with it the largest deforestation rate. Within 3 years (2001 until 2004) more than 540.000 hectare were cleared, peaking at a deforestation rate of 23% in 2003. Forests are cleared for cattle ranching and farming. With the increasing need for cropland also pasture is transformed to agricultural land resulting in further clearings. The relationship between cropland expansion and deforestation in the state of Mato Grosso is displayed in Figure 11 Mechanization of forest clearing and agricultural production push the intensification of land use. Deforestation activities and the soy bean price are positively correlate which can be confirmed with the increase of large-proportion clearings during favorable markets and vice versa.

In addition to the land demand for plantations, forests have to make way for new big transportation routes from the plantations to the harbors. The soy boom has justified massive infrastructure projects under government programs such as *Brazil in Action* and *Forward Brazil* which have a dragging effect (subsequent damage) on biodiversity on top of the effects of the soy cultivation itself [Fearnside 2001]. Railways to connect north-south routes, highways and waterways with soy terminals are constructed and expanded. Already cleared land close the the routes is popular farmland sold at high prices. These dragging effects are left unconsidered in the current environmental impact statement that issues the licenses for farms.

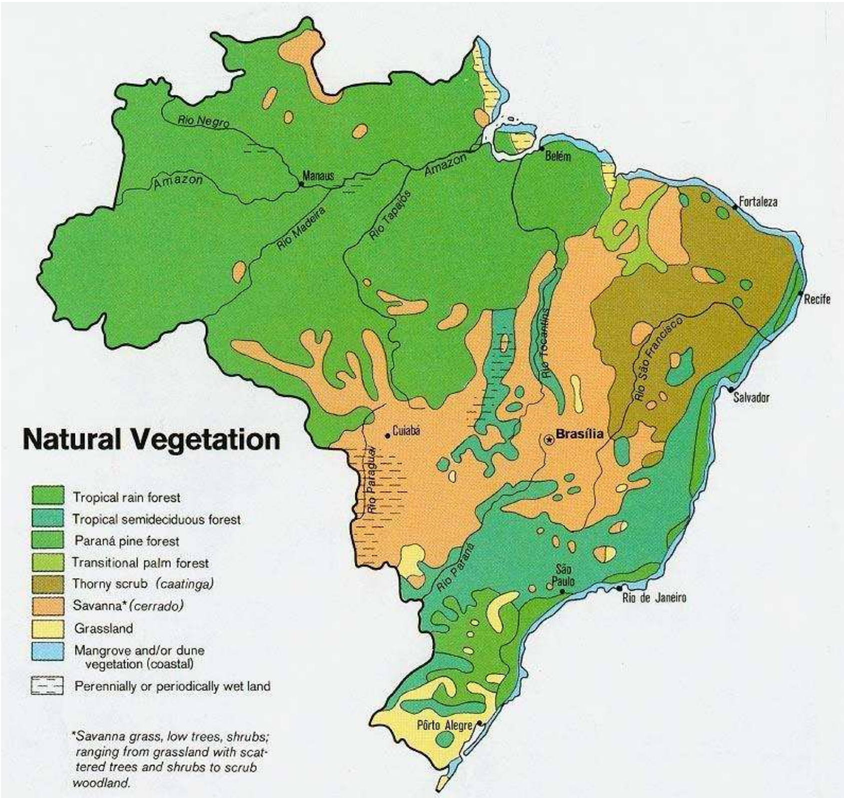

Figure 12: Vegetation types of Brazil from 1977

Originally the Atlantic forest stretched over on area of 1 million km^2 along the Brazilieean south-east cost. As the largest vegetation type in Brazil it inhabits 20000 plant species and is home to numerous bird species, insects, and mammals. But its biodiversity falls victim to the deforestation and dragging effects connected to soy production. Today less than 10% of the original forest remain since large areas were subject to deforestation for timber and cattle ranching as well as for sugarcane, coffee and soy plantations [Conservation International]. Rapid economic development in Brazil has pushed the process of land conversion and brought heavy industry into the region. Connected issues are air and water pollution along with forest and biodiversity loss.

Another endangered ecosystem threatened by soy is the cerrado, a scrub savanna with grassland and trees. The cerrado is the least protected ecosystem in Brazil even though it is a biodiversity hot spot and the largest vegetation type after the Amazon forest and serves as an important water reservoir in this dry region. With an area of 2 million km^2 on the central Brazilian plateau the cerrado covers 20% of Brazil [WWF.org]. This special ecosystem is adapted to dry seasons and frequent fires that maintain the vegetation balance, recycle nutrients and help with germination. Its diversity covers many endemic plants, birds, mammals, and insects. Yet 80% of the original area has been destroyed with agricultural production and cattle ranching [Conservation International](see Figure 13). In the cerrado 58% of Brazils soy and 70% of all farm outputs is produced [Pearce 2011].

Cerrado soils are not suitable for agriculture but with some soy species tolerant to low soil phosphate and high aluminum the advance into the cerrado was made. Government financial support as a motor for the extension of agricultural areas also play an important role in this development [Fearnside 2001]. To ensure that soy stays competitive with other crops on the market it is heavily subsidized by the Brazilian government. Subsidies keep the prices low and the farmers are paid a minimum price for their harvest.

Conservation for cerrado biodiversity has been ignored for too long. Today only 2% of the area is protected and the Amazon forest code (which states that 80% of forest land has to be left intact) does not apply to the cerrado.

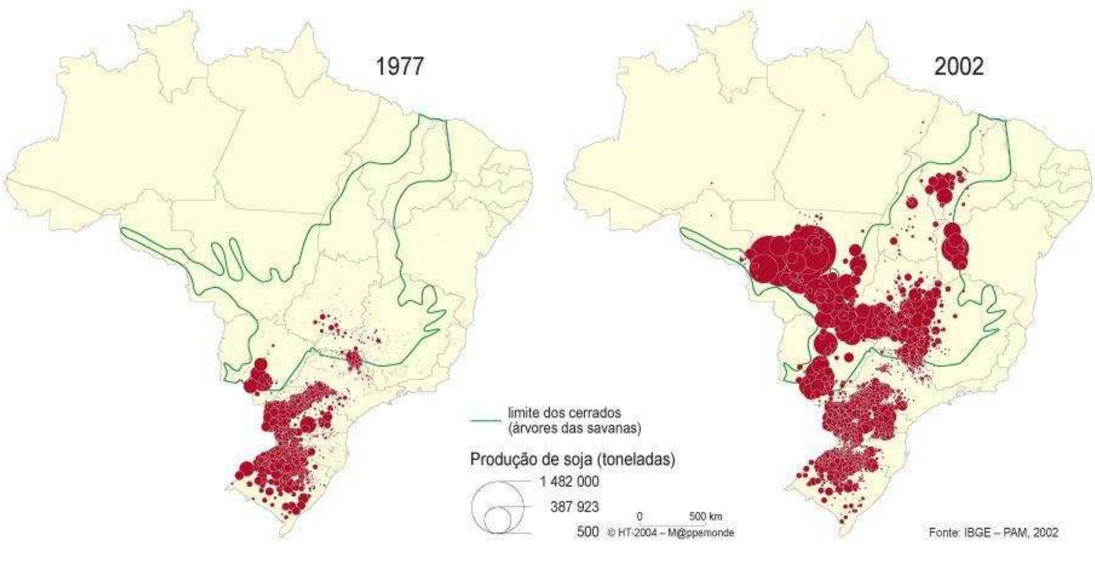

Figure 13: Expansion of soy from 1977 till 2002

5.2 Decline in Soil and Water Quality

Figure 14: Watershed of crop land in North and South America

Deforestation and industrialized farming greatly affects and reduces soil quality. Because of a lack of diverse root network and pesticides that kill other weeds and plants, the soil is vulnerable to exposure to sun, wind and rain. The nutrients are easily washed out by the rain and pesticides too run off into rivers and groundwater. The use of heavy machinery, mono-cultures and chemical fertilizers cause erosion, sedimentation, soil compression and salinization processes. These accelerate soil degradation resulting in floods, droughts, erosion, desertification and landslides [Steward 2007]. Erosion is responsible for 85% of agricultural land loss world wide with an average annual erosion rate of 30 to 40 tonnes per ha [Clausing 29.3.2011]. Therefore, soil exhaustion and erosion present major problems in soy cultivation and need to be tackled for sustainable cultivation. Warnings from the Brazilian Ministry for Agricultural about unsuitable soil conditions in certain regions for cultivation, or only under the charge of “well defined technical criteria” were ignored by farmers [Clay 2004]. Because of the mono-crop cultivation and use of pesticides, important soil organisms disappear and with them their functions to recycle nutrients. Further organic substance is lost because killed weeds and stems left over after harvesting are cleared which greatly reduces the humus content in the soil and its carbon capturing capacity. Thus, soil also plays an important role for the carbon balance and the loss in soil quality due to intensive agricultural practices also affects the world climate. Climate changes have caused floods and droughts that threaten food security.

The function of forest as water reservoir, wind buffer, and nutrient recycler are lost with forest clearing. As mentioned before, fertilizers and agrochemicals run off into rivers where they poison or even kill fish. Negative health effects from fish and contaminated drinking water have been presented [Lanje 2005]. Land use change to intensive agriculture has caused degradation of freshwater resources. The water quality suffers from erosion, pollution by fertilizers and chemicals and salinization greatly affecting flora and fauna in the whole watershed. These land-use changes also reduce water quantity since 70% of the withdrawn fresh water is used for agricultural irrigation [WRI 2003]. Almost half of that water does not reach the crop but is lost through runoff and evaporation because the watering systems are often ineffective, adding to water scarcity in many regions. The map in Figure 14 presents the distribution of watershed with intensive cropland development in North and South America.

The rivers are not only contaminated but subject to straightening and construction of hydroelectric dams in the course of the extending waterways and infrastructure extension causing yet more dragging effects. For more arable land cultivation is extended to unsuitable areas that require more irrigation, even wetlands are drained and lost. Hence, biodiversity and water as a natural commodity are affected indirectly but profoundly [Fearnside 2001].

5.3 Waterbalance

The virtual water content of a product is estimated by the amount of water consumed during its production process. In the case of soy, we need to consider the water used in the seed and chemical producing industry, on the plantations for growing, harvesting and for further processing. For soybeans the virtual water content is estimated at some 2500 m^3 per ton soybean.

The soybean share in the overall crop-related virtual water trade makes up 17% [Hoekstra 2003]. Virtual water trade can also become a socio-economic problem when water-rich countries import water-intensive products from water-poor countries. Virtual water trade, thus, has relevance to water scarcity and food security because of the water used for production in exporting counties [WRI 2000]. In the case of soy the water trade balance depends on the regions where it is cultivated and how much precipitation it receives. Next to precipitation also chemicals, processing and transport need be considered and are generally quite high irrespective of the region. Measuring the exact water content of a product is difficult because methods are not available for all production processes. The more processing steps a product undergoes the higher is its water balance is. When soybean meal is used for feeding cattle, the virtual water of the soy production is added to the production of the meat. In comparison, one kilogram of soybeans uses 1800 liters of water and one kilogram of beef (fed with soy or other crops) uses approximately 15500 liters of virtual water during production [Waterfootprint.org]. Thus, soy also plays a role in virtual water trading where water inequalities between exporting and importing regions are intensified.

5.4 Land Use Change and Carbon Balance

In the USA and the EU soy is grown on fields that were already in agricultural use, in contrast to Brazil or other tropical countries where natural habitats are cleared and bioms of high diversity such as rain forest or savanna are newly converted for agricultural land [Clay 2004]. The expansion and occupation of areas with annual crops such as soy and cattle farming are direct changes in land use since agriculture is being established in formerly isolated environments. Migration and the construction of infrastructure are just a few of the indirect results of land use change which have ecological dragging effects and result in habitat loss [Tomei et al. 2010].

How does land use change effect the carbon balance of soy production? Deforestation alone emits vast quantities of carbon, be it through burning where CO_2 is directly released into the atmosphere or be it the loss of high biomass where carbon is stored as a product of photosynthesis. Planting soy on former high biomass areas therefore creates a negative carbon balance since the soy plants cannot compensate for the loss. Furthermore, carbon above and below ground is released by exhausted, eroded soil because of deficient soil organisms and organic substance contributing to rather than mitigating climate change [Tomei et al. 2010]. Therefore, Dauvergne and others propose to plant soy on already degraded or cultivated land to stop additional forest conversion and reduce net carbon emissions. Using soy for biofuels adds to the negative carbon balance which is further discussed in 6.2.

5.5 Land Rights and Migration

Colons (small farmers) and family farms in Brazil live on and cultivate land where land rights and ownership are not clearly defined. Some areas have been traditionally cultivated for a long time which gave them no legal but accepted land use rights. However, these traditional land use rights conflict with the property rights of legal owners. In contrast to Bolivia, where until 1994 all land belonged to the state and could only be leased, in Brazil "land rights include indigenous claims, colonial holdings, resource extraction claims, grazing rights, and land settlements" [Hecht 2005].

Therefore, many areas have complex legal claims and overlapping land rights from private and state owners. Additional difficulties arise where governments have sold land to companies that was colonized by other settlers or farmers before. They then are banished from their lands and move on to other areas where even more forest is cleared for cultivation [Dauvergne and Neville 2010]. The idea is that claiming land justifies clearing it. When land shifts from state to private ownership, it usually becomes an area of commercialized agriculture [Hecht 2005].

Because indigenous people's and traditional farmer's land rights are not accepted and very limited, there is also no support for local infrastructure and social networks. Family farms and communities try to connect but in many cases living conditions worsen because pressure to sell the land is put onto them which drives them off their lands to the cities or Amazon region frontiers. Unfortunately, it is not unusual for conflicts between small farmers and big companies to be resolved trough violence or just "clearing and claiming" [Hecht 2005]. Small farmers cannot survive next to the industrialized farms since they are displaced from their land and are not needed for labor. Therefore they move to the cities to live in the expanding city slums(favelas) [Bertrand 1984].

Not only farmers but also indigenous people are affected. Two indigenous cultures still live in the Atlantic forests and are being expelled from their lands which leads to subsequent damages connected to migration such as poverty and further land use change.

5.6 Economic Inequity and Dependency

To establish soy plantations the land must first be cleared work-intensively which is usually done by cheap labor forces. Later on, the plantations can be managed by just a few workers since most tasks are mechanized. "The response to high market prices and cheap production cost in Brazil is more soy production. Trade arrangements with China and the EU increase Brazil's export earnings and attract more foreign investment" [Steward 2007]. These earnings are used to pay for national debts. The individual farmers do not see much of this revenue and cannot keep up with the big farms since although all farmers are paid the same guaranteed minimum price for soybeans only the big farms can benefice with quantity.

"But since soy cultivation needs heavy capital investment in machinery, land preparation, and agricultural input,[. . .] the establishment is concentrated on wealthy entrepreneurs and not suitable for poor farmers" [Fearnside 2001] As explained in section 4.4 farmers are dependent on the seed contracts with the big agricompanies. The technology packages promise higher yields at lower prices but agricompanies hold monopolies not only on the GM seeds but also on the whole soy production process (since they also own mills etc.) and can later raise the prices. Farmers have no choice but to buy the seeds at higher prices or give up to the competition [Fearnside 2001]. With the increase of private actors in the agrarian sector, the power to enforce regulations through government institutions is weakening [Tomei et al. 2010].

5.7 Working Conditions and Health

Government funding focuses on agriculture subsidies rather than on local priorities like education and health [Tomei et al. 2010]. This development leads to mechanized and specialized soy cultivation which reduces employment on large farms where one worker is sufficient for 160 - 200 ha [Fearnside 2001]. The distribution of workers per 100 hectar inFigure 15 shows that regions with industrialized farming offer fewer jobs for farmers.

Migrants are encouraged to come for clearing and preparation of the land but further employment is not guaranteed. Workers have neither legal protection nor wage guarantee [Bertrand 1984]. Since most plantations are worked by farmers who do not own the land, they have no interest in the long-term protection of the land but rather in short-term profit [Tomei et al. 2010].

Often unskilled workers are not acquainted with the use of chemical pesticides or even heavy machinery. Wrong handling due to illiteracy, lack of health information and training on the use of chemicals results in severe health issues inefficient and often too heavy application of pesticides. Pesticide spraying not only directly affects the workers but also causes health problems in rural communities and as a secondary effect spreads even further into rivers and ground water. Higher rates of cancer, skin- and respiratory diseases and an increase in birth malfunctions and miscarriages have been observed. Despite a law that prohibits spraying close to rural communities, fumigation continues [Tomei et al. 2010].

Next to pesticides, GMOs also represent hazards. Studies on health effects from GM soy have shown“cellular change in organs, more acute signs of aging in the liver, enzyme function disturbances, and changes in the reproductive organs [...] in experimental animals” [Antoniou et al. 2010].

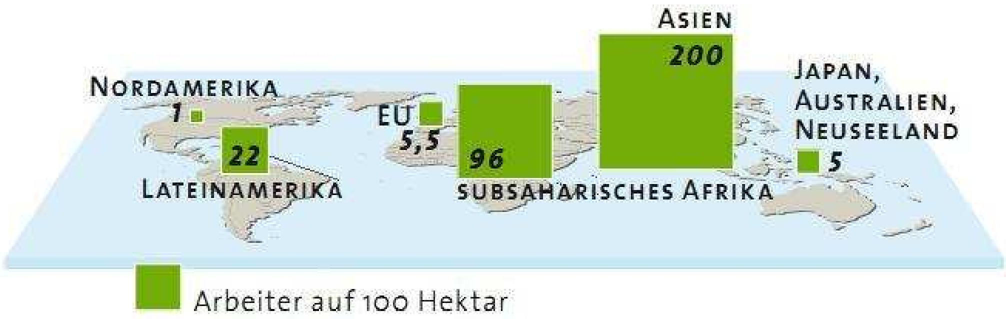

Figure 15: Worldwide distribution of workers per 100 hectare

5.8 Food Security

Small farmers grow rice, manioc, and black bean for their own consumption and some sell soybeans on local markets. If these small farmlands are taken over, families are bereft of their food source and livelihoods. Even though the Brazilian agriculture produces enough calories to feed everyone, prices on the local market are too high for the poor to afford it. Rural people lose their food sovereignty and need to live off expensive imports [Tomei et al. 2010]. Large parts of the cultivation areas are exclusively used for world market export commodities. Therefore, even raising crop yields is not a solution to the hunger of the local population. The problem will grow even more acute if food crops are being replaced with oil crops to meet the demands of the increasing biofuel production [Berthelot 2009]. The demand for biofuels as a substitute for fossil fuels (not only in the face of depleting resources but also because of high oil prices) was a major factor in the dramatic rise of world food prices in 2008 resulting in the aggravation of world hunger [FAO 2009].

With the expansion of soy fields, areas for local food production and consumption are lost. So-called “land grabbing”, the purchase or long-term leasing of large areas by big agricompanies, leaves many farmers without livelihoods and constricts the land use. Since food crops such as soy are also used for biofuels (see 6.2), land competition between food and fuel arises and influence the world market prices of food crops. The commodification of food production results the small farmers losing control of their own food production, which is now controlled by market forces [Clausing 28.3.2011].

With the change from soy as human food to animal food proteins become less available for humans. Energy and proteins are lost in meat production instead of making direct use of them by eating vegetable food. Bertrand stated that animal and plant proteins do not have the same value, therefore both are needed. But feeding animals with human food is a waste, creates unnecessary cost and intensifies food insecurity.

6 Globalized Conditions

Globalization as the integration of the world's economies and cultures is too broad a term to be defined here. I want to focus on some aspects of economic and political conditions related to soy production on a global scale namely liberalization of world markets, technology transfer, shift from state control to strong private sectors and more or less direct impacts and inequities for the people dependent on soy agriculture.

6.1 Agricultural Industrialization and Globalization

To understand the extensive development of soy it is helpful to look at the history of its industrialization. Soy has been cultivated in China for human consumption for a long time. Export of soy started only the 19th century and small farm production changed to big export-oriented production. At the beginning Europe was mainly interested in soy as animal feed. It was mixed with other meals to reduce fodder prices. With the intensification of livestock breeding and growing meat consumption, soy became more attractive. Meat, milk, and eggs could be sold at lower prices and the combination of corn and soy in animal feed offered both energy and protein. In the US soy growth increased rapidly when production firms cooperated with farmers and offered them guaranteed minimum prices (similar to government subsidies). Since the Marshall Plan of 1947, Europe entered into more and more trade cooperation with America and in turn received stabilized currencies and rehabilitation after the war.

The Brazilian soy boom, which started in the 1960s [Lanje 2005], is closely connected to the American trade embargo in 1973. The oil crisis in 1973 (embargo from Arab countries to the US) coincided with severe droughts in Africa which led to protein shortage and rocketing food prices. Europe and Japan then sought to dissociate from the American market also in terms of soy since the USA imposed an embargo on soy exports [Lanje 2005].

Instead they turned to Brazil for soy where it had formerly been mainly used as feed for cattle farming. First, Brazil only concentrated on soybean production for export but later with increases capacities also started processing with more capacity and then even imported soybeans from Argentina and Paraguay. With export taxes on soybeans being higher than on processed soybean meal and soy oil, the processing industry advanced. Economic reforms in Brazil helped to modernize not only production but also infrastructure. Today, soy is responsible for 1,5% of the GNP (gross national product) [Abiove et al. 2010].

After 1980 the Amazonian countries experienced opening markets and trade liberalizations due to a political transition to democracy. Hopes were that financial profit would result in modernization and social progress. But companies rather than the government managed the development primarily determined by land ownership and economic (rather than political) progress [Hecht 2005]. The effects of this development in Brazilian agrarian politics have been discussed in the earlier chapter. Soy has become an important pillar of the US and the EU agrarian politics as well since its economic range extends across many sectors from agriculture to transport, industry for machines, seeds and fertilizers, food industry as well as cooperations with services for credits, research and science.

Higher productivity and yields due to technically specialized processes ensure more capital income to all industries involved in the soy production and also to the state earning from export taxes [Bertrand 1984]. These tight economic bonds and dependencies between production and consumption on an international scale are a pattern of globalization. The outcomes for the food industry, for example, are changed consumer habits, more convenience products and higher meat consumption. In the course of soy expansion and the use of soybean meal for cattle and poultry farming, animal products have become cheaper and available in higher quantities. Campaigns to eat more animal protein changed the diet towards a higher meat consumption even in Southeast Asia and in turn boosted the demand for soy.

Influences on the food market have been far-reaching. How could Brazilian soy oil affect the olive oil market in Tunisia? Instead of consuming olive oil locally, Tunisia imports cheap soy oil for its own food industry (partly mixing it with olive oil) and exports its olive oil to participate in the global market. Another example of globalization example is the Senegal, where locally produced peanut meal (also rich in protein) was replaced by soybean meal since soy imports are cheaper than the local peanut production [Bertrand 1984].

New markets in the so-called “global south” opened up and trade relations among developed and less developed countries established, especially in South America and East Asia. Within South America, Argentina, Paraguay, Bolivia and Brazil have active trade relations. These markets mimic the trade between north and south while “powerful economies are deepening relationships with MNCs” [Dauvergne and Neville 2010]. Brazil plays an active role as a link in North-South-South trade where developed countries in the south and investors from the north create new markets in other less developed country in the south. This strategy secures Brazil a strong political and economic position on the international market. These dynamics in the producing countries tend to focus on short-term profits at the expense of environmental degradation and social dislocation. Since a large proportion of the southern states’ economies depends on the international market, they are more vulnerable to price and demand fluctuations and the political power executed by the northern countries and MNCs.

6.2 Biofuels from Crops

“The global political economy of biofuels emerging since 2007 appears set to intensify inequities among the countries and rural peoples of the global south” [Dauvergne and Neville 2010]. To use soy as renewable energy source creates similar environmental and social problems as discussed earlier but also starts a new debate about the carbon balance and the attempt to mitigate climate change with biofuels.

The Biofuel Directive imposed by the EU in 2003 to reduce greenhouse gases and mitigate climate change led to an increasing demand for soy as feedstock for biofuels. In 2006 20% of the biomass for German biodiesel production came from soy and palm [Burgermeister and Writer 2007]. Biomass energy ought to be used for power, heat and transport. But with that, new problems arise since biofuel sources compete with food crops and the ecological benefits compared to fossil fuels, namely carbon emission reduction or even carbon neutrality, become invalid when new land is converted and cleared for crop cultivation. An intact forest stores much more carbon in its biomass than can be captured with crops. When forest is cleared or burned, carbon is released just as well as further emissions occur when biofuels are burned. Therefore, the positive effect on the carbon footprint of biofuels from crops, often promoted as green energy, is highly questionable. When calculating the carbon profits of biofuels, effects from land use change and life cycle emissions of cultivation cannot be overlooked. But data for these calculations are lacking [Tomei et al. 2010]. In fact, "the efforts to meet reduction commitments through biofuels may actually speed up climate change through carbon releases from forest conversion and may additionally undermine other environmental commitments, including the *Convention on Biological Diversity*" [Dauvergne and Neville 2010].

As rising crop prices led to a global food crisis in 2007, it became clear that yet another issue arises from the biofuel solution, namely food security. In this case, food and fuel from the same crop are tightly connected and compete. The destructive patterns of forestry and agriculture are similar in the biofuel industry because the already existing agriculture can be easily changed and extended from food to fuel. It can be assumed that it will not be the public benefiting from this development but the MNCs and local governments [Dauvergne and Neville 2010] involved in this sector. Marginal rural groups losing land, work, food and community are ignored in this intensifying process.

Biofuels as non-petroleum based fuels are made up of bioethanol, biodiesel, and biogas with the processing of feedstock being the difference between them. The carbohydrates (sugar and starch) from sugarcane (*Saccharum officinarum*), corn (*Zea mays*), and wheat (*Triticum aestivum*) are used to produce bioethanol while the extracted oils from soy (*Glycine max*), oil palm (*Elaeis guineensis*), rapeseed (*Brassica napus*) and sunflower (*Helianthus annuus*) are used for biodiesel. Biogas is made from fermented biomass. A distinction must be made between first, second, and third generation biofuels. First generation biofuels are derived from food crops such as soy, corn or sugarcane whereas second generation biofuels use non-food crops such as ryegrass, switchgrass, husks and stems of corn, and other crop leftovers. The third generation biofuels are derived from algea biomass and lipids for which research and development are still ongoing to make this technique feasible. Algea as fuel source holds many promises because it does neither compete with foodcrops nor arable land or even fresh water sources [Schenk et al. 2008].

Brazil produced 88 million liters biodiesel per month in 2007 [Giersdorf 2007], half of which is derived from soy. But soy is not an ideal biodiesel crop since its oil (at most 20%) is only a side product of the actual soybean meal product while palm oil achieves much higher oil yields per hectare (but has also devastating ecological impacts). Competition with food and land makes soy even more unsuitable as source for biodiesel.

The carbon and energy balance of biofuels and the potential for a positive effect on climate change not only depends on the kind of feedstock but also on how they are cultivated and produced (agricultural methods, land use, pesticide application, technology) as well as on the policies regulating these matters. Guidelines for emission saving and sustainability criteria for establishing renewable energy sources, such as required by the EU, could counteract additional carbon savings. This is because the carbon balance for biofuels with the cultivation and production processes as well as the ecological damage from mono-crop cultivation that cause carbon emissions need to be taken into account.

When forest is cleared above-ground biomass and below-ground roots are removed and carbon is lost [Morton et al. 2006]. At the moment, food crop production for biofuels in Brazil and Southeast-Asia cause a negative carbon print rather than a positive contribution to climate change.

6.3 Privatization of Agriculture

Since the produced soybeans are not directly traded with the end consumer there are always processing firms and agribusinesses in between. Many of them are big multinational corporations (MNCs) that control most of the capital flow between producers and consumers because they own the production and processing technologies and sometimes even the transport fleets [Bertrand 1984]. Large areas of land are bought from private ownership or from the state and farming is privatized by agricompanies. This leads to diminished state control over production and state of its agriculture.

The North-South and the North-South-South trade relations are pushed by large MNCs establishing in the producing countries. Agricultural and chemical companies seize the chance to join the markets and cover larger shares of it and directly control cultivation, like *Monsanto*. When MNCs team up with local firms, state control over the sector weakens. This is because local firms often trade up protection by their state for better technology access and capital from multinational partners and ownership shifts from public to private. Strong MNCs and large farms then displace small-scale production and small landholders from the market. States are especially at risk of losing control to firms when they focus their production on export or even on just one or a few commodities and trade economic benefits for corporate control. Then MNCs can control whole sectors like the agriculture, forestry, and energy industry in a country. These processes also reinforce the exclusion from benefits and marginalization of rural groups, small farmers, and other communities from the market [Dauvergne and Neville 2010].

The farmers' dependences on seed contracts with the agricompanies have been explained in 4.4. But not only seeds and chemicals are in the hands of MNCs. Many also own the processing mills and production chains with binding delivery contracts with the farmers. When the only mills in the region are in private hands, farmers have no choice but to sell at the proposed price.

6.4 Subsidies and Certificates as Market Tools

Subsidies are financial support from the government and a tool to navigate a country's economy on the world market. The US subsidizes soy production in form of minimum price guarantees for the farmers, no matter how the harvest will be. With that, the price on the world market can be set low and secured to be competitive. The US subsidizes its soy production with several hundred million dollars per year, keeping the world market price low and securing its competitiveness over other soy countries. Because of this market advantage, Brazil appealed to the WTO (*World Trade Organization*) to curb US subsidies. "The World Trade Organization in April and June 2004 concluded that the US government subsidies of $12.5 billion between 1999 and 2002 were an unlawful interference with free trade. Without them, the WTO concluded in a case brought by Brazil, the US production and exports would have been lower and world prices would be higher" [Migration 2004].

Still, the Brazilian government also generously subsidizes infrastructure development projects that boost the soy industry. Consequently, the state's interest in the development of the soy market in exchange for reliable revenues from export taxes is safe. Economic, not to mention ecological sustainability, can most likely not be achieved with these interests.

After complaints about the devastating ecological and social impacts of soy from NGOs and consumers became louder, certificates were established as a tool to meet the market demand for more transparency. Certified GM-free soy is now produced separately in response to consumer pressure especially from Europe. Ingredients must be labeled by their origin. Furthermore, fair trade certified products are on the rise. This niche market obtains premium prices. But questions arise on whether certificates can lead to sustainability which shall be discussed in the following chapter.

7 Solutions for Sustainability

Questions about how to make soy production sustainable and to mitigate its negative effects naturally arise when you look at the impacts. In the literature used for this thesis, different approaches to the environmental and social challenges were suggested. Here, I want to outline some of these solutions. First, the much stated *Round Table on Responsible Soy* with leading industry participants and second, the Fair Trade certification scheme with focus on social sustainability. Then, two best-practice examples, one with a theoretical and one with a practical focus on sustainable soy production will be outlined. Finally, I will present collected solutions with different ecological or political emphasis.

7.1 Certificates

One well known and frequently cited approach to sustainability is the *Round Table on Responsible Soy* (RTRS) Association, "a multi-stakeholder forum with a membership including NGOs such as WWF (*World Wildlife Fund*) and *Solidaridad*, and multinational companies such as *ADM, Bunge, Cargill, Monsanto, Syngenta, Shell*, and *BP*" [Antoniou et al. 2010]. Its publicity is due to its influential members and vigorous commercializing of the "green" company images.

Founded in 2005, the goal is to create "auditable principles and criteria for use with a certification scheme" [RTRS 2010] for responsible soy production. These principles are to become the basis for countries to use and adapt into national legislation and certification. Producers and producer groups who want to be certified must follow the criteria and provide proof of constant monitoring. In any case, all RTRS principles are based on assessments, monitoring and documenting to ensure transparency on one hand but can also cause quite heavy intense bureaucracy on the other. The main principles are:

1. Legal Compliance and Good Business Practice
2. Responsible Labor Conditions
3. Responsible Community Relations
4. Environmental Responsibility
5. Good Agricultural Practice

These embrace the socio-economic impacts like compliance with legal land rights, refusal of child labor or slavery of any kind (in accordance with the *International Labor Organization's Convention*), support of safe and healthy workplaces (see Figure 16), communication with local communities and fair employment to name but a few. For environmental impacts, principles include the assessment of pollution, emissions, dragging effects of infrastructure projects, control of land expansion, support of good agricultural practice which includes protection of the ground water, other water bodies and soil as well as responsible handling and documentation of all agrochemicals used. A detailed list of the criteria can be found in appendix.

Figure 16: Compulsory protective masks

Techniques proposed in the RTRS criteria to avoid soil erosion relate to conservation agricultural practices that include no-till farming, crop rotation and maintaining soil cover during and after cultivation. For the control of land expansion, maps shall be (but have not yet been) created to show areas with six different values of conservation (HCV=High Conservation Value) ranging from globally significant biodiversity to areas important for local food production. Official land use maps ranging from biodiversity hot spots to already intensively used agricultural land are also being used. In accordance with these maps the RTRS agreed to not extend the clearing for soy production into native habitats after May 2009 [RTRS 2010]. This does not apply to areas that have already been used for cultivation (also traditional land use) as long as they do not have the status of native forest. Additionally, *ABIOVE* (the Brazilian Vegetable Oil Industry Association), and other members of the RTRS "pledged not to trade soybeans originated from areas within the Amazon Biome deforested after July 2006" [Abiove 2007]. This is known as the Soy Moratorium.

Despite its well-intended criteria, the ability of RTRS to address environmental and social impacts of soy has been challenged and criticism arose because GM soy was not prohibited in the principles [Tomei et al. 2010]. Worthy of criticism is the principle of controlling land expansion because the native habitats stated in the criteria only include primary forest and do not consider secondary forest as "area of high conservation value".

In contrast to the RTRS, the Fairtrade certificate is an international label (see Figure 17)for many consumer products from mostly developing countries supporting small-scale producers, good working conditions and organic cultivation. As stated in the generic standards "Fairtrade is a strategy for poverty alleviation and sustainable development. Its purpose is to create opportunities for small-scale producers in the south who have been economically disadvantaged or marginalized by the conventional trading system. If fair access to markets under better trade conditions would help them to overcome barriers to development

Figure 17: Fairtrade label

and empowerment, they may join Fairtrade". The Fairtrade standards of FLO (*Fairtrade Labelling Organization International*) follow the standards of the *International Labour Organization*, the *Declaration of Human Rights* and the respective national legislations (unless they are below internationally recognized standards) [FLO 2009]. Small producers are supposed to create producer organizations who then contract with the Fairtrade Organization to whose standards the producers need to comply. The organization needs to meet minimum requirements some of which shall be presented here. The complete Fairtrade standards can be reviewed in the appendix.

For social development the minimum requirements are:

- Creation of a development plan based on democratic and transparent norms
- Training and education of the members of the organization for administrative functions
- No discrimination (as stated in the *Universal Declaration of Human Rights*)
- Direct support for members from disadvantaged or minority groups

In terms of socioeconomic development the agreements are:

- Producers can earn a Fairtrade premium additionally to the payment for products when the organization is managed transparently and the premium use documented
- The producer organizations should gradually become more involved in the whole trading process become independent and achieve economic sustainability

For environmental development producers need to comply with the environmental protection measures as part of the farm management. This includes:

- Assessment, planning and monitoring of cultivation impact
- Prohibition of clearing native forest
- Planting of buffer zones and encouraging regeneration of flora and fauna
- Constant reduction and strict monitoring of the use of agrochemicals
- Compliance with the list of prohibited materials of Class I A&B of the WHO (*World Health Organization*), the "Dirty Dozen" from PAN (*Pesticide Action Network*) and FAO (*Food and Agriculture Organization*) plus specific Fairtrade standards to reduce toxins in water, soil and plants for human safety and environmental protection
- Training for safe handling and storage of chemicals
- Reduction of waste through recycling (use of organic material for mulching)
- Conservation of soil fertility through tillage and cultivation methods preventing erosion
- Managing water sources and ground water quality

- Prevention of uncontrolled fires with training in fire clearing
- Prohibition to use genetically modified organisms in any part of the product chain

Labor conditions are an important aspect of the Fairtrade certificate. Employment policies imply:

- No discrimination and prohibition of punishment and abuse
- No child labor (persons under 15 years and special safety requirements for persons under 18 years) and slavery
- Right of association and worker's organizations
- Contracted employment (with binding written contracts) with fair wages, set regulations for sick leave, working hours and maternity leave
- Provision of a healthy and safe working environment which includes training with hazardous substances, protective clothing and hygienic sanitary facilities [FLO 2009]

There are inspections to verify that the producers comply with these standards (at least in form of a management plan) before they get accepted for the Fairtrade certificate. All components of a product and all stages of production (storage, transport, processing, handling) must conform with the Fairtrade standards. Producers sign binding purchase contracts with the buyers at fixed producer prices (at least the minimum prices set by the Fairtrade Organization for each commodity). The goal is to create long-term trade relationships for economic sustainability. The minimum prices for soy from conventional and organic production are displayed in table 1.

Table 1: Minimum price for fair trade soy. SPO=small producers organization, USD=U.S.Dollar, MT=metric ton, EXW= delivery ex works

Status: 31. Mar 2011							
Product (specific product standard)	**Product variety**	**Price applies to**	**Currency / Quantity x Unit**	**Price level / *special price conditions**	**Fairtrade minimum price**	**Fairtrade premium**	**Valid from**
Soybeans (Soybeans and Pulses)	Conventional	worldwide (SPO)	USD / 1 MT	EXW	355,00	35,00	05. Dec 2008
Soybeans (Soybeans and Pulses)	Organic	worldwide (SPO)	USD / 1 MT	EXW	510,00	50,00	05. Dec 2008

The *Transfair* label has been established for many products (coffee, chocolate, flowers, tee, some fruits and more) and aware consumers willingly pay premium prices for fair traded products. Still, Fairtrade only makes up a very small part of the food export market since most commodities are produced in mass production and on an industrial rather than small scale. To set fair environmental and social standards for production "[...]certification schemes alone will not be enough to create the appropriate public policies that will protect the health and food security of citizens[...]" [Tomei et al. 2010] and a turning away from monopolistic large scale production might be needed.

7.2 Best-Practice Examples

There have been several attempts of finding solutions for the environmental and social problems imposed by soy production most of which focus on management plans and certificates to make soy more sustainable. Here, I will introduce two projects with different emphases, one methodical and one practical but both with certificates as tool for mitigation of negative impacts from soy production.

In LANJES book *Stoffstom Soja* links between Brazilian soy production and German livestock farming in Lower Saxony were studied by creating complex communication (with conferences) between local and international actors on all stages of the soy value chain. The goal was to integrate all actors into the discourse to produce a sustainable soy certificate similar to the FSC (*Forest Stewardship Council*) label embracing the principles of the UN Agenda 21 passed in 1992 in Rio de Janeiro. A small selection of principles embraced in this project are:

- The right for development (3rd principle of Agenda 21)
- The reduction of life standards inequity (5th principle of Agenda 21)
- The special focus on the environment in developing countries (6th principle of Agenda 21)
- The protection of indigenous peoples (22nd principle of Agenda 21)

Results of the conferences through panels of experts for each subject area have lead to the following consensus. All participants agreed that sustainable soy cultivation includes the task to stop deforestation and advance into the cerrado and Amazon forest, promotion of direct planting methods (seeds are planted directly after harvesting without further tillage) to prevent soil erosion and the use of fallow land as well as the ban of genetically modified seeds (this principle caused *Monsanto* to leave the board). The social component of sustainable soy from this project aims to create work and life opportunities for small farmers and workers to avoid land migration and supports the establishment of local administration to control legal land and work issues. It was suggested to add value to the Brazilian market by directly exporting meat instead of only exporting soy for meat production elsewhere. But this was not in the interest of the livestock farmers in Germany (and other meat producing countries) nor was the recommendation to reduce meat consumption. Furthermore, animal products (meat, milk products, eggs) should be labeled with the origin of soy fodder to make it more transparent for the consumer. Consumer awareness can create more pressure on soy producers.

With these and other criteria a certificate for sustainable soy ought to be created where environmental and social guidelines can be adapted according to the local conditions. Help with the process and control of certification can be obtained from the *EcoCert Organization* and financial support has been granted by the German GTZ (*Gesellschaft für technische Zusammenarbeit*) [LANJE 2005].

The idea of using certification as a tool to promote sustainability has been picked up in many forms. One local certification approach I want to shortly present is the management program *Soja Plus* in Brazil where "sustainable practices and environmental adaptation of rural property" [Abiove et al. 2010] achieved by producers will lead to a *Soja Plus* Certificate. Partners of the project are the Brazilian Ministry of Agriculture (*Embrapa*), universities and other state research institutes. In the process of the management plan four fields of action were declared. Namely, legal compliance, social responsibility, environmental sustainability and best agricultural practice. Detailed principles can be found in the appendix. The instruments are: collecting field data, training and educating rural producers in technical practices, establishing and monitoring best management practices and rewarding compliance with certificates. The management program is based on the pillars of already established environmental programs such as the RTRS (see 7.1), the Soy Moratorium (to create reserves up to 80% of the native vegetation when extending soy fields to create reserves), the general guidelines for work conditions and others [Abiove et al. 2010].

Figure 18: Capanema region cooporating with gebena Brasil

Certification is practically implemented by the Swiss company *gebana Brasil* who consciously work on a small scale with local farmers to produce non-GM and fair trade soybeans. Gebana's first contract with small local farmers from the Capanema region (see Figure 18) dates back to 1997. Since then a trade relation has been established where gebana today has direct contracts with more than 250 farmers who produce *Demeter*, organic and fair trade products. Long before, these farmers have decided "to abandon agrochemicals [...] and solve the fundamental problems of [...] impoverishment and migration [in the region]". Gebana has picked up on these decisions and found that "fair trade of organically produced soya with small producers opens up new prospects for the region's future". Farmers get payed 40 to 100% more for organic soy than the local market price. Certification for environmentally and socially sustainable, non-GM, organic soy was established.

Today more than 250 farmers produce for and benefit from this schema. The organically grown soybeans are checked several times during the process for genetic engineering since gebana wants to guarantee that no traces of GM-soy are found in its products. The farmers deliver the beans directly to gebana's warehouse in Brazil and further processing to soybean meal or oil is done on-site. From there the products are shipped directly to Europe and checked again to be GM-free. Representatives from gebana pay frequent visits to the farmers. The trade relation between gebana and the farmers is described as follows "the cooperation with producers is carried out on the basis of cultivation contracts for one or more years. *Gebana Brazil* provides advice on organic methods of cultivation and organises and finances seeds, fertilisers and biological pest control for the producers. In return, the producers commit themselves to deliver the crops and to comply with the terms and conditions". Farmers also grow many other products for own consumption in order to be independent of soy. [gebana Brasil] Still, I would like to challenge this trade relation as it resembles the dependences of farmers from large corporations just on another scale because gebana still controls the seeds and does all the export. However, many aspects of the concept like organic and fair trade production as well as on-site and small-scale production resemble the Fairtrade standards and are a step in the right direction towards sustainable soy production.

7.3 Potential Ecological and Political Solutions

Many studies have dealt with the problems and impacts of soy production and many solutions have been suggested. Here I will introduce a few possible answers and approaches from the literature used.

- Bertrand suggests solutions to the tight dependencies and inequities in the soy related market. Grass and regional food (also other legumes) should be fed to animals in order to reduce the soy imports (and still assure nutritious feed). At the same time, Bertrand notes that expansion of industrialized animal farming must stop and meat consumption should be reduced. These solutions are, of course, neither in the interest of animal breeders not the fodder producing industry nor the crop producers which represent the better and influential part of the soy complex.

- Dauvergne sees a necessity for state governments to stay in control over the domestic and international trade market relations for which the state needs strong networks with the private sector to prevent loss of control over the market dynamics to MNCs. If the state is able to control the market, it can also enforce standards for environmental and social interests. Decentralized state governance could be a possible solution for more control. Voluntary private programs (and certification schemes) have proven to be not very effective because of the absence of sanctions for non-compliance.

- The conservation strategies Clay focuses on the creation of protected areas on already existing agricultural land. The problem of erosion should be addressed with no-till practices and terracing. Cover crops should be enforced and mulching increased to built up organic matter in the soil. He suggests using degraded and abandoned land for cultivation instead of clearing new habitats. This could be achieved if credits for land were linked to this requirement as compensatory payment. Further, installing better control and monitoring mechanisms to avoid environmental degradation and ensure legal compliance with regulations is important. Policies that address the environmental issues are needed, subsidies that encourage soy expansion need to be removed and instead best management practice (BMP) and conservation agriculture should be rewarded.

- On top of that, Hecht's conservation approach focuses on the value of fragmented forest which can be used as corridor ecosystems and function to protect watershed, avoid soil erosion, block wind, and serve as a habitat for plants and animals. In the cerrado, forest islands need to be kept or established to do just that. Political programs need to put more priority to succession areas and corridor ecosystems not only in rural but also urban open spaces and parks.

8 Conclusion

As we have seen, soy developed to a “cash crop” in the consequence of market economy development of the world trade, the opening of the world market, the increasing demand for cheap animal food because of growing meat consumption, and the surge of fossil fuel alternatives with biofuel from soy to name but a few.

The ecological consequences of soy production in Brazil range from loss of biodiversity through deforestation to eroded soil and contaminated water sources caused by intensive agriculture practices. Privatization and the growing power over the soy market of large MNCs leads to loss of land and employment and economic inequity of local farmers and rural population. Additional consequences of the soy production in Brazil are health risks connected to pesticide use and the threat to food security with a growing one-commodity, export-oriented market. Certificates for so-called sustainable soy are not sufficient to address all aspects outlined in this thesis. I agree with the proposed solutions in 7.3 for conservation agriculture methods. But ecological and socio-economic sustainability for Brazil can only be achieved with a change in policies and an emphasis on the domestic market.

Soy production falls short of the hopes and promises made by those promoting its development. It does not present a solution to world hunger (ironically despite the increased yields) since it is only an export commodity and occupies agricultural area for local food production. Soy biodiesel is not a climate-friendly alternative because of high carbon emissions due to deforestation and loss of the soil's carbon-capturing function. Plus, the devastating impacts on biodiversity, the loss of forest along with soil and water quality through transgenic and mono-culture soy cultivation leaves little hope for sustainable production.

An approach to the loss of land and employment from industrialized, export-oriented agriculture can be regulations based on food sovereignty and strengthening of the domestic markets to become independent of the export markets. For that, local governments need to be aware of the impacts these dependencies have on local people and the environment. Only the political will to protect one's own land, people, and markets and to enforce the needed policies can ensure ecologically, socially, and economically sustainable development. As suggested by Berthelot, agriculture needs to be withdrawn form the power of the WTO (*World Trade Organization*) to give scope for the country to focus on sustainable development.

To strengthen the domestic market means protection of agricultural products for local consumption and production. Development of sustainable and diverse cultivation of traditional crops like rice, manioc, and beans as well as market prices competitive with export crops on the local market are needed. Local markets can be strengthened and the situation for small farmers improved when small-scale production is supported with the understanding of sustainable economy. In that way food security can be ensured and Brazil's agriculture can gain independence from the dynamics of the world market. Under the given conditions of soy as export commodity, sustainability in an ecological and social sense is not possible because of the unsustainable nature of an expanding market economy. Fearnside sees it more drastically and explains that “Expansion will only stop when supply exceeds global demand [...] then prices fall to make soy trade unprofitable”.

Local institutions can often address problems of the people and land better than national institutions since they have direct access to the people. But their influence is often underestimated and no power and funding is given to them since production is large-scale and legislation standardized. I think that decentralized institutions could provide better direct services for health, education and access to markets. Training for safe handling of chemicals and education about ecological cultivation methods as well as direct marketing are important for rural development and independence of farmers. Legal charges enforced by local governments for environmental protection can be monitored much more regularly and difficulties recognized and dealt with directly.

Since the development of the soy boom is consumer-driven, I think that a change towards sustainable soy production would also be consumer-driven. As we have seen, small-scale production under fair trade conditions is possible since consumers demanded it and are willing to pay higher prices for it. It was consumer pressure which led to the prohibition of GM soy in certain regions and products was enforced. But for consumers to be able to use their power (i.e. their purchasing power) awareness about the dramatic ecological and social impacts of the current soy production and its dynamics is needed. I hope that the impacts summarized in this thesis can create awareness and serve as initiation to also change consumer habits (i.e. reduce meat consumption) and look behind a product's packaging.

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10 Appendix

Please refer to the CD for additional datafiles

- Criteria from the Round Table on Responsible Soy, in [RTRS 2010]
- Subjects of compliance from the Soja Plus program, in [Abiove et al. 2010]
- Generic Fairtrade Standards for Small Producers' Organizations, in [FLO 2009]

Eidesstattliche Erklärung

Hiermit versichere ich, dass ich diese Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Außerdem versichere ich, dass ich die allgemeinen Prinzipien wissenschaftlicher Arbeit und Veröffentlichung, wie sie in den Leitlinien guter wissenschaftlicher Praxis der Carl von Ossietzky Universität Oldenburg festgelegt sind, befolgt habe.