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Study

Is the EU a Major Driver of Deforestation in Brazil?

Quantification of CO_2-emissions for Cattle Meat and Soya Imports

Carina Zell-Ziegler

GERMANWATCH

HNE Eberswalde
Hochschule für nachhaltige Entwicklung

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The English and German Abstracts of the study have been extended and updated for publication in 2016 – 2017. They now relate to the latest developments.

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Publisher:
Germanwatch e.V.
Bonn Office
Dr. Werner-Schuster-Haus
Kaiserstr. 201
53113 Bonn, Germany
Ph.: +49 (0)228 / 60 492-0, Fax -19

Berlin Office
Stresemannstr. 72
10963 Berlin, Germany
Ph.: +49 (0)30 / 28 88 356-0, Fax -1

www.germanwatch.org
E-mail: info@germanwatch.org

Contact the author: c.zell-ziegler@oeko.de

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Abstract

Where is the problem?

Reducing greenhouse gas emissions to limit global warming to well below 2°C or even to 1.5°C, as emphasised by world leaders in the Paris Agreement reached in December 2015, can only succeed if deforestation is cut dramatically in the next decades because the resulting emissions nearly make up one fifth of all greenhouse gas emissions worldwide.

Most of the world's deforestation is happening in South America and in Africa. Brazil has been the country with the largest deforestation for many years. It is far away from Europe, so can we lean back and put all responsibility for causing the emissions on Brazil? No! We need to look at the drivers of this deforestation to develop effective climate change mitigation policies – and here the EU is clearly involved.

Deforestation in Brazil, especially in the Amazon rainforest and the Cerrado savannah, happens mainly due to the establishment of pastures for cattle as well as cropland to grow soya. Cattle meat and soya – as beans, cake or meal – are very important export goods of Brazil, and this is where international demand, hence the EU as the world's third largest net importer of agricultural products comes into play. This study tries to answer the question "Is the EU a major driver of deforestation in Brazil?" and quantifies the CO_2-emissions resulting from deforestation caused by the production of beef and soya that is imported from there.

This quantification includes an estimation of indirect land use change (iLUC) due to the prevalent pattern that much of the soya is planted on former pastures thus not directly leading to deforestation but indirectly because its expansion is boosting new deforestation for the displaced cattle pastures. For this purpose an own country- and situation-specific method was developed.

Alarming Study Results

Up to 18 % of Brazilian deforestation emissions were caused by the imports of the EU

The results reveal that the EU has been the largest foreign driver of deforestation in Brazil in the years between 2002 and 2006. In 2005, the year with its largest impact, the EU was responsible for 19 % of deforestation which equals about 780,000 ha and consequently for 200 million tons of CO_2-emissions, which corresponds to 18 % of Brazilian deforestation emissions, see Figure 1.

After 2006 the impact of the EU on Brazilian deforestation emissions was reduced. This was due to the sharp decline in Brazilian cattle meat imports in 2007 due to an outbreak of foot-and-mouth disease in Brazil and import restrictions of the EU as well as a drop in the estimated rate of deforestation linked to establishing soya plantations from 2006 on.

Other major players: Russia and China

Hence, in 2008, Russia had overtaken the EU with a share of 5 % in Brazilian deforestation emissions while the impact of the EU had decreased to 2 %. At the same time, China's impact increased so that it only ranked very closely below the EU in 2008.

For the EU, soya is the most relevant import commodity causing deforestation in Brazil

Within the calculated deforestation emissions caused by the EU, deforestation due to soya plantations makes up about ¾ whereas deforestation due to cattle pastures makes up ¼. This distribution is the result of including iLUC, which is omitted in many other studies, hence these underestimate the influence of soya. Since a systematic occupation of pastures by soya, on average after eight years, is described in literature (Macedo et al., 2012), the associated deforestation emissions from iLUC could be calculated and were reallocated from cattle to soya.

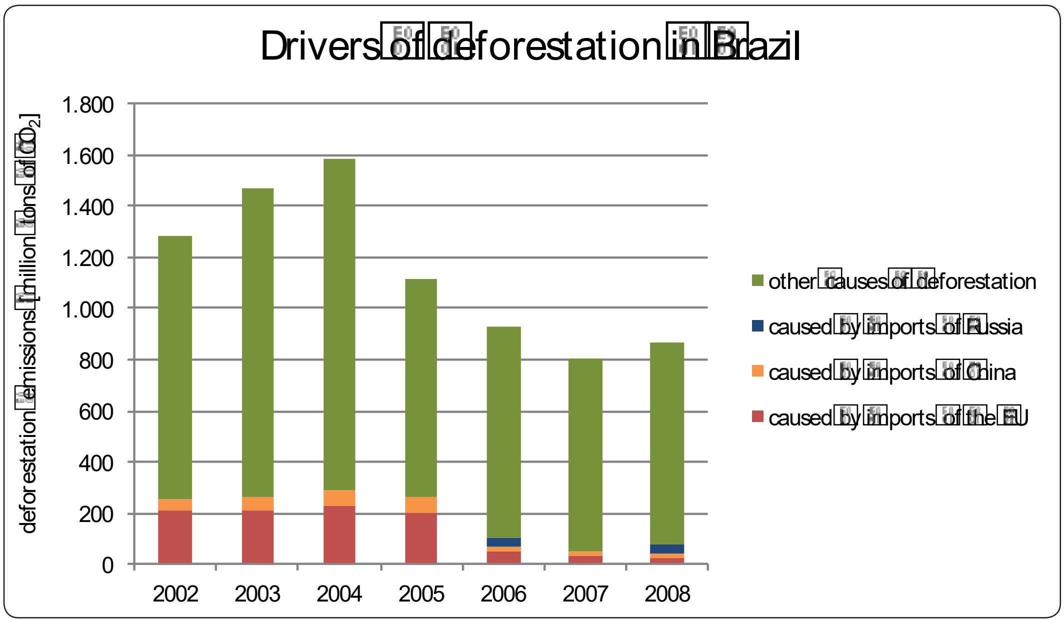


Figure 1: Results from linking Brazilian deforestation emissions with imports of soya and cattle meat by the EU, China and Russia between 2002 and 2008, own figure and calculations.

Overall, the results of this study show that the EU has been a major driver of deforestation in Brazil in the years 2002 – 2008. More recent studies, e.g. by the European Commission on "embodied deforestation" confirm these results (European Commission, 2013).

Recent developments: Improvements but no resolution

At the time this study was written, data (especially for Cerrado deforestation) was only available until 2008. To relate the results to more recent developments, this abstract has been extended and completely updated.

Deforestation: Stagnation at lower levels

Let's have a look at deforestation first. As can be seen in Figure 2, deforestation in the Amazon has been rather constant in the last few years at about 5,000 to 6,000 km^2 per year. This is only about 1 / 5 of what has been deforested in 2004 but the area is still as large as twice the size of the German federal state of the Saarland.

Quantifying deforestation in the Cerrado remains a problem as there are no good satellite systems yet. That is why besides the information on average deforestation between 2002 and 2008 data could only be updated until 2010. Deforestation in the Cerrado seems to have decreased quite a lot to about 7,000 km^2 per year.

Despite this reduction, Brazil still has the world's largest annual deforestation by area (FAO, 2015). A deforestation hotspot that has not been considered in this study is the Atlantic rainforest, with massive deforestation due to soya as well (WWF, 2014).

Were established policies and measures successful?

The decrease in deforestation in the Amazon and the Cerrado shows that some of the deforestation policies and measures were effective. These are among others improved law enforcement, the Soy Moratorium, which was renewed indefinitely in May 2016, the Forest Code, restrictions for farmers in those counties with the highest deforestation rates to get agricultural credits, satellite monitoring, the increase of protected areas and the restoration of degraded areas.

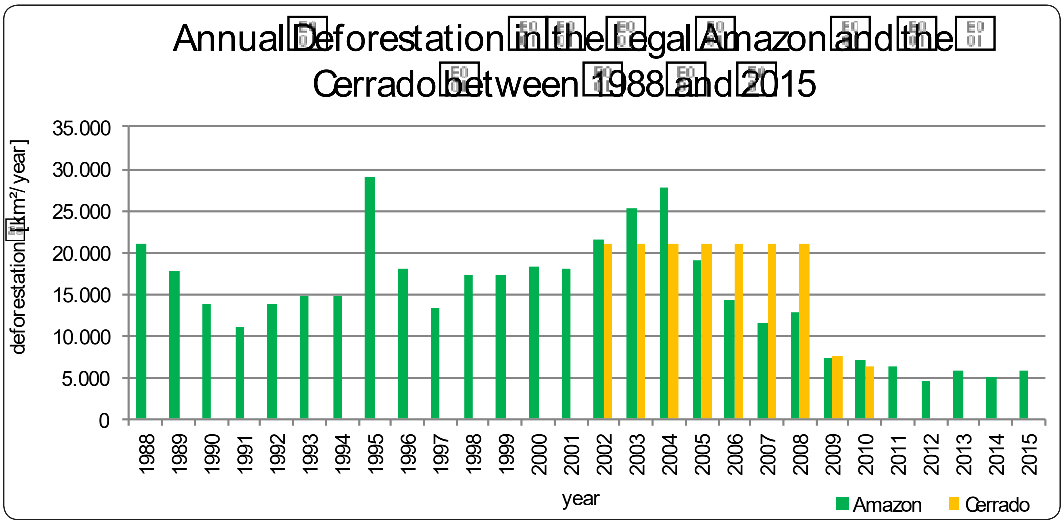


Figure 2: Development of deforestation in the Amazon and the Cerrado. Own figure, data from INPE, Brazilian Government (2009) and Portal Brazil (2012).

However, this success is not granted to remain in the coming years: The new Forest Code grants an amnesty for illegal deforestation that took place before 2008 and its trading mechanism for deforestation rights is highly controversial, finally, the size of some protected areas was reduced (Gibbs **et al.**, 2015; Soares-Filho **et al.**, 2014).

Let's have a closer look at what happened in the Amazon in the last years: Soya production increased quite a lot between 2007 and 2012 whereas beef production is more or less stagnating since 2008. At the same time, beef production became more intensive and the number of cattle per area increased. This led to an excess of pastures which were then used for soya production; this contributed to the lower deforestation rates (Nepstad **et al.**, 2014).

Cattle ranching and soya production shift more and more to the Cerrado where about 70 % of Brazil's farm output is produced (Pearce, 2011) because there is no Soy Moratorium, no such good satellite monitoring and so on (Nepstad **et al.**, 2014). According to NASA (2015) the Soy Moratorium in the Amazon actually shifted deforestation to the Cerrado in recent years.

Another aspect that makes the Cerrado vulnerable to deforestation is that only 8.24 % (168,000 km^2) of the Cerrado are officially protected and only ⅓ of these are in strict Protection Areas (PAs). Françoso **et al.** (2015) investigated deforestation rates in the different protection zones and found that deforestation rates in sustainable use PAs did not vary a lot from those outside PAs. Only the deforestation rates within the strict PAs were considerably lower.

Outlook: The future of the Amazon and the Cerrado is totally unclear

Will Brazil achieve its deforestation reduction goals and keep deforestation, also in the Cerrado, low? Nepstad **et al.** (2014) are not sure whether law enforcement and economic incentives are sufficient and point out that there is still 120,000 km^2 of forest area outside of protected areas in the Brazilian Amazon that is profitable for conversion to soy.

The Brazilian Government itself draws diverse pictures of the future of the Amazon. As a basis for the Brazilian INDCs (Intended Nationally Determined Contributions) that were developed in the run-up to COP21 in Paris in 2015, INPE (the Brazilian National Institute for Space Research) developed three scenarios. They range from an optimistic scenario with restoration and conservation measures exceeding those foreseen in the Forest Code to a pessimistic scenario in which the environmental advancements of the past are setback. In the optimistic scenario where clear-cut deforestation and forest degradation processes are stopped and secondary vegetation is increased, the Amazon becomes a carbon sink after 2020. In the pessimistic scenario, deforestation rates rise again in combination with other problems like chaotic urbanization.

Recent data on soya and cattle production and trade

Between 2010 and 2014, the soya area harvested in Brazil grew by 30 %, hence it was as large as the size of Italy (more than 30 million ha) in 2014 and had a share of 40 % of all Brazilian cropland. Along with the United States and Argentina, Brazil accounts for around 9 / 10 of global soybean exports (WWF, 2014). Since 2010, exports rose by nearly 50 %. Cattle meat exports from Brazil rose by 24 % between 2010 and 2013 (FAOSTAT and UN Comtrade).

Recent data on soya and cattle imports of the EU

For imports, there are different pictures for soya and cattle. Whereas soya imports into the EU declined by about 10 % between 2010 and 2014, cattle meat imports rose by nearly 60 %. For both commodities, Brazil remains the main trading partner of the EU.

Concerning soya, out of the other important exporters in South America, Paraguay and Uruguay considerably increased their soya area and worldwide exports. The EU also drastically increased their imports from these two countries between 2005 and 2010 (+482 % from Uruguay and +173 % from Paraguay, data from UN Comtrade). Going together with the decrease in European soy imports in the last few years, these high levels are decreasing. The figures lead to the conclusion that for soya, the EU is not the main driver of cropland expansion anymore, China is now the largest soy importer by far.

For cattle meat, Uruguay and Argentina are the other major trading partners of the EU besides Brazil but their cattle meat export is more or less constant to decreasing in the last years. With regard to the increasing cattle meat imports from Brazil, the EU is again increasing its impact on deforestation.

Multifaceted picture

This analysis of the recent developments shows a picture with many facets. Deforestation was considerably reduced, but for the Cerrado there is no information on the latest developments. The Forest Code which shall protect the forest seems to contribute to deforestation in the Cerrado and protected areas do not guarantee zero deforestation. Soya and cattle are still expanding on forested lands or former pastures and the Brazilian economy is highly and increasingly dependent on the export of these commodities. It is clear that the EU is still contributing to deforestation in Brazil, and therefore needs to look at options to reduce its impact.

(Political) conclusions

Conclusions from this study address three different levels. At first, deforestation within Brazil needs to be decreased by appropriate measures like effective law enforcement, more ambitious goals for deforestation reduction, an increase in strict protection areas and the installation of a good real time deforestation detection system also for other biomes than the Amazon. Furthermore, the usage of abandoned and degraded cattle pastures for further agricultural expansion should be supported. Leakage and iLUC can be avoided by national approaches on deforestation reduction rather than single goals for the different biomes, by a closer collaboration of the cattle, soya and biofuel sectors as well as by more participatory processes. Additionally, more reliable instruments for transparency should ensure compliance with voluntary agreements like RTRS better.

Secondly, the EU should reduce its impact in Brazil. This can be reached by stimulating the production of certified, deforestation-free products with its demand and imports. There is already good practice for other import goods like biofuel where sustainability standards are regulated in the EU renewable energy directive. The partnership agreement FLEGT for timber trade is another example

which could be transferred to soya, beef meat and other commodities. As a consequence, certain sustainability criteria would have to be met by imported products and the EU would help exporting countries in reaching them.

The EU should also set itself broader sustainability goals that include the reduction in virtual land use and hence deforestation emissions abroad. By a goal like this also pesticide use, land conflicts with the local population, land degradation and other problems in the exporting countries could be addressed. Going together with a reduction in virtual land import is the increase in self supply of the EU with protein-rich animal feed. The promotion of these crops, which are also good for the nutrient enhancement of the soil, is already ongoing within the “European Protein Strategy”. However, more decisive action in terms of research, breeding of suitable and adapted species, consultancy and trainings is needed.

Another aspect the EU’s strategy should include is the reduction of meat production and consumption. The meat production of the EU is not just driven by domestic demand but exports, especially to Africa, play a huge role and destroy local markets. Therefore, all incentives that foster meat export should be abolished. Furthermore, an awareness campaign in the EU for a healthy diet with less meat can reduce meat consumption.

Thirdly, all nations should include the halt of deforestation more into their climate change mitigation efforts and strengthen instruments to halt deforestation like REDDplus. Moreover, by integrating the full environmental costs from deforestation into the price of all products, e.g. by carbon taxes, a decrease of deforestation worldwide could be triggered. Furthermore, it seems to be quite important to focus more on consumption-based greenhouse gas accounting and to join forces and financial means to reduce the demand-driven emissions. Therefore, the virtual land use and the related emissions need to be quantified, like shown in this study or by the European Commission (2013). Like that, the consuming and the producing countries can address them effectively together.

Calculation Methods and Steps

In the following three figures all calculation steps used for this study are visualized.

At first, direct land use change was calculated by using given areas and emissions of deforestation and / or emissions factors for the Amazon and the Cerrado. Using percentages from the literature, these deforestation emissions were then allocated to soya and pasture conversion of the two biomes. By multiplying these results with the proportion of these commodities exported to the EU the direct deforestation emissions of the EU were calculated (see Figure 3).

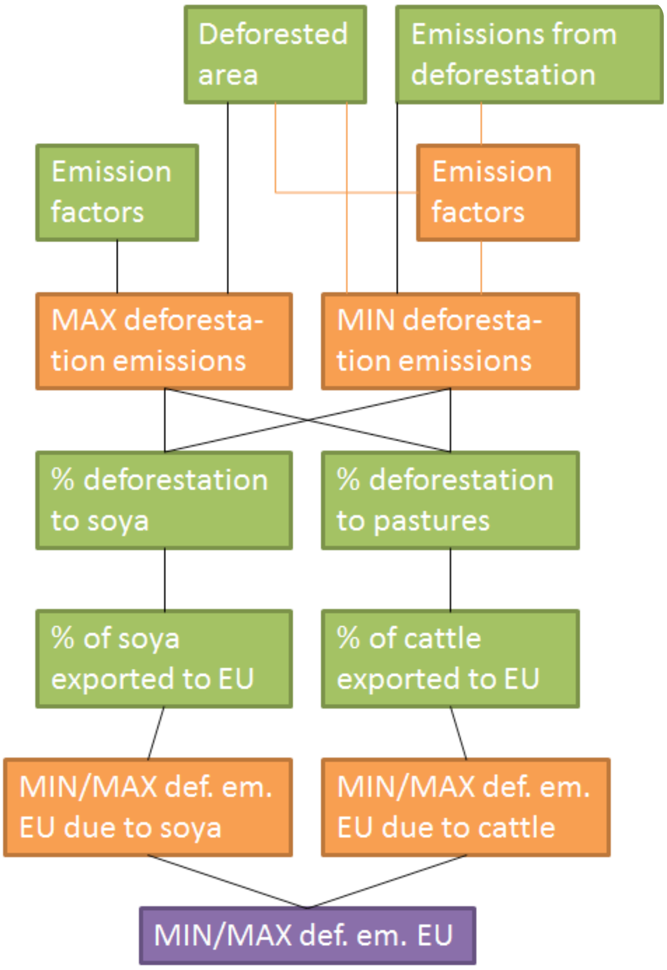


Figure 3: Emissions from direct land use change – calculation steps.

Colour code:
Green = data from the literature;
Orange = calculated;
Purple = result.

Notes:
(1) The same method was used for Amazon rainforest and Cerrado.
(2) For deforestation emissions there was no complete time series given in the literature. Therefore, the emissions for the missing years have been calculated using calculated emission factors from previous or following years and the deforestation area (orange lines).

To calculate iLUC emissions, data from the literature on the area of soya plantations, on the occupation rate of soya on pasture and on the average conversion patterns were needed to calculate on the one hand the emissions of the area firstly occupied by pastures and then by soya and on the other hand the share in time between soya and pastures (see Figure 4).

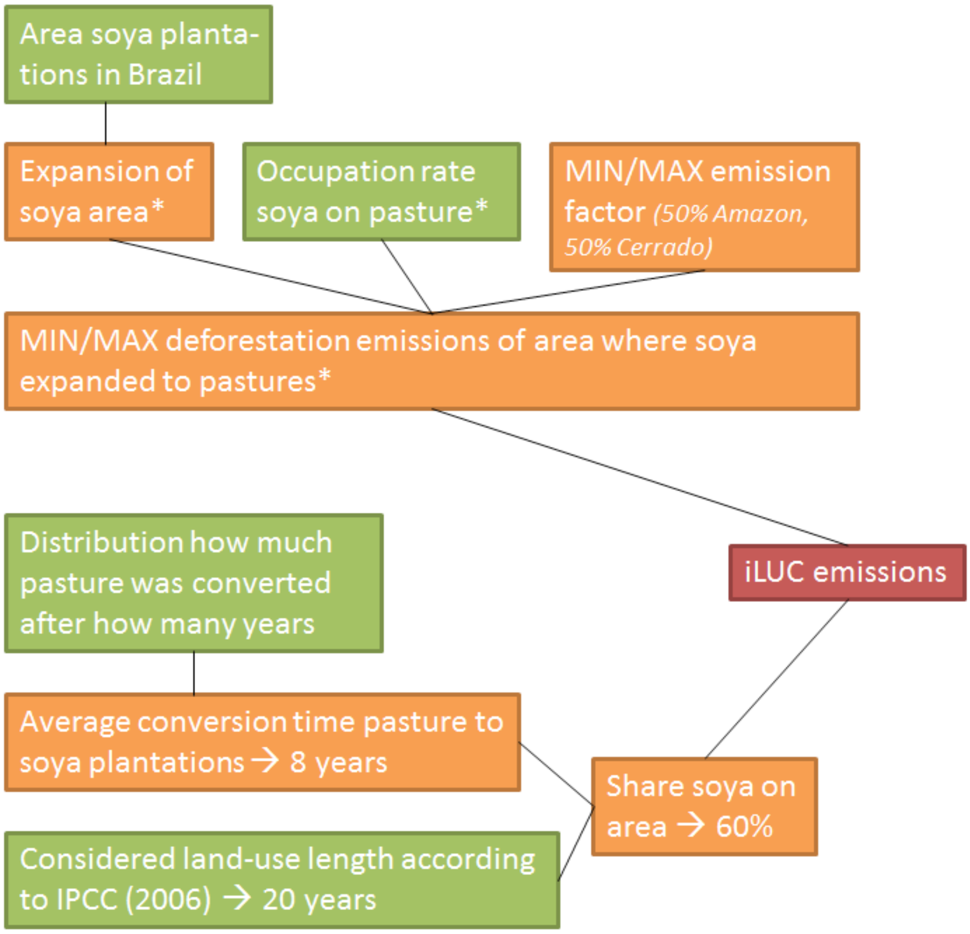


Figure 4: Emissions from indirect land use change – calculation step 1.

Colour code:
Green = data from the literature;
Orange = calculated;
Red = result iLUC.
*** Differentiation for the periods 2011–2005 and 2006–2010.**

In a second step these iLUC emissions were redistributed between cattle and soya. The resulting emissions were again multiplied with the proportions of these commodities exported to the EU to get the EU's deforestation emissions including iLUC from its imports of cattle and soya from Brazil (see Figure 5).

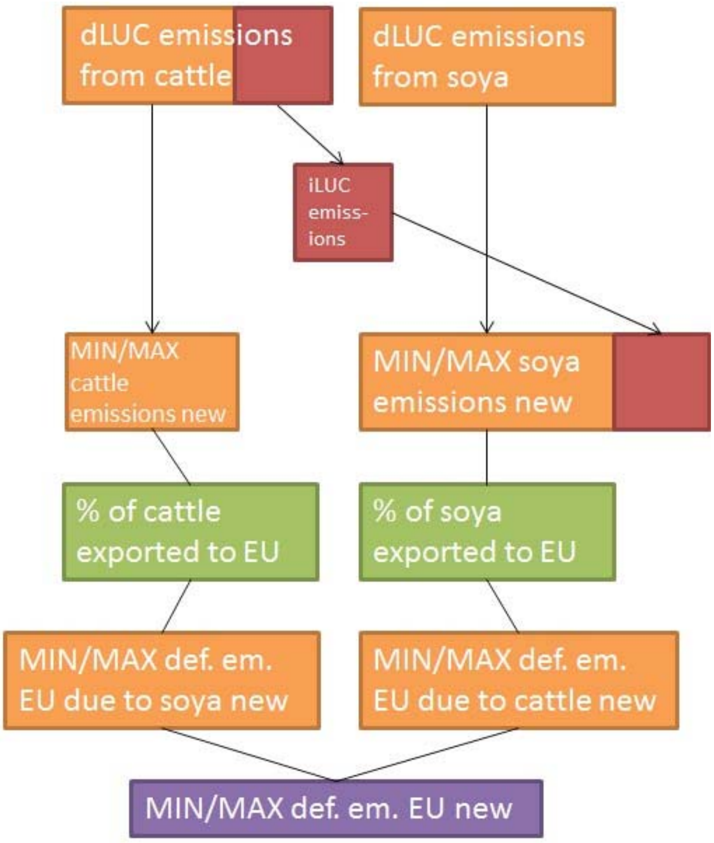


Figure 5: Emissions from indirect land use change – calculation step 2.

Colour code:
Green = data from the literature;
Orange = calculated;
Red = result iLUC;
Purple = result.

Zusammenfassung

Problembeschreibung

Die Reduktion der Treibhausgasemissionen, um die globale Erwärmung auf unter 2°C bzw. sogar unter 1,5°C zu begrenzen, wie es die Staats- und Regierungschefs in der „Pariser Vereinbarung“ im Dezember 2015 vereinbart haben, kann nur gelingen, wenn die Entwaldung in den kommenden Jahrzehnten drastisch reduziert wird. Denn die dadurch freigesetzten Emissionen machen fast ein Fünftel der weltweiten Treibhausgasemissionen aus.

Der Großteil der weltweiten Entwaldung findet in Südamerika und Afrika statt. Brasilien ist seit vielen Jahren das Land mit der höchsten absoluten Entwaldung. Es liegt weit von Europa entfernt, können wir uns also zurücklehnen und Brasilien die gesamte Verantwortung für die freigesetzten Emissionen aufbürden? Nein! Wir müssen uns die Verursacher dieser Entwaldung ansehen, um effektive politische Maßnahmen zu deren Vermeidung zu entwickeln – und hier ist die EU ganz klar gefragt.

Die Ausbreitung von Rinderweiden und Ackerflächen für den Sojaanbau ist hauptverantwortlich für die Entwaldung in Brasilien, vor allem im Amazonasregenwald und der Cerrado Savanne. Rindfleisch und Soja – als Bohnen, Schrot oder Mehl – sind sehr wichtige brasilianische Exportgüter. An dieser Stelle kommt die internationale Nachfrage, und damit die EU als der weltweit drittgrößte Nettoimporteur von landwirtschaftlichen Produkten, ins Spiel. Die vorliegende Studie versucht die Frage zu beantworten, ob die EU eine der Hauptverursacher für die Entwaldung in Brasilien ist und quantifiziert die CO_2-Emissionen, die durch die Entwaldung für das importierte Rindfleisch und Soja entstehen.

Diese Quantifizierung beinhaltet eine Abschätzung der indirekten Landnutzungsänderung (indirect land use change, iLUC), wonach ein Großteil des Sojas auf ehemaligen Rinderweiden angebaut wird und somit nicht direkt, sondern indirekt zu Entwaldung führt. Seine Expansion führt zu neuer Entwaldung, da für die durch den Sojaanbau verdrängten Rinderweideflächen neu gerodet wird. Zu diesem Zweck wurde eine eigene landes- und situationsspezifische Methode entwickelt.

Alarmierende Studienergebnisse

Bis zu 18 % der brasilianischen Emissionen aus Entwaldung wurden durch Importe der EU verursacht

Die Ergebnisse zeigen, dass die EU zwischen den Jahren 2002 und 2006 der größte ausländische Verursacher für Entwaldung in Brasilien war. Im Jahr 2005 war die EU für 19 % der Entwaldung verantwortlich, was rund 780.000 ha und Emissionen in Höhe von 200 Millionen Tonnen CO_2 – bzw. 18 % der brasilianischen Emissionen aus Entwaldung – entspricht, siehe Abbildung 1.

Nach 2006 nahm der Einfluss der EU auf die Entwaldung in Brasilien ab. Grund dafür war der drastische Rückgang der Rindfleischimporte aus Brasilien im Jahr 2007, welcher durch einen Ausbruch der Maul-und-Klauenseuche in Brasilien und Importbeschränkungen der EU sowie eine Reduktion der angenommenen Entwaldungsrate durch die Etablierung von Sojaplantagen ab 2006 verursacht wurde.

Andere wichtige Player: Russland und China

2008 hat Russland die EU mit einem Anteil von 5 % an den brasilianischen Entwaldungsemissionen überholt, die EU reduzierte ihren Anteil hingegen auf 2 % der Emissionen. Gleichzeitig nahm auch der Anteil Chinas zu, so dass es im Jahr 2008 nur knapp hinter der EU rangierte.

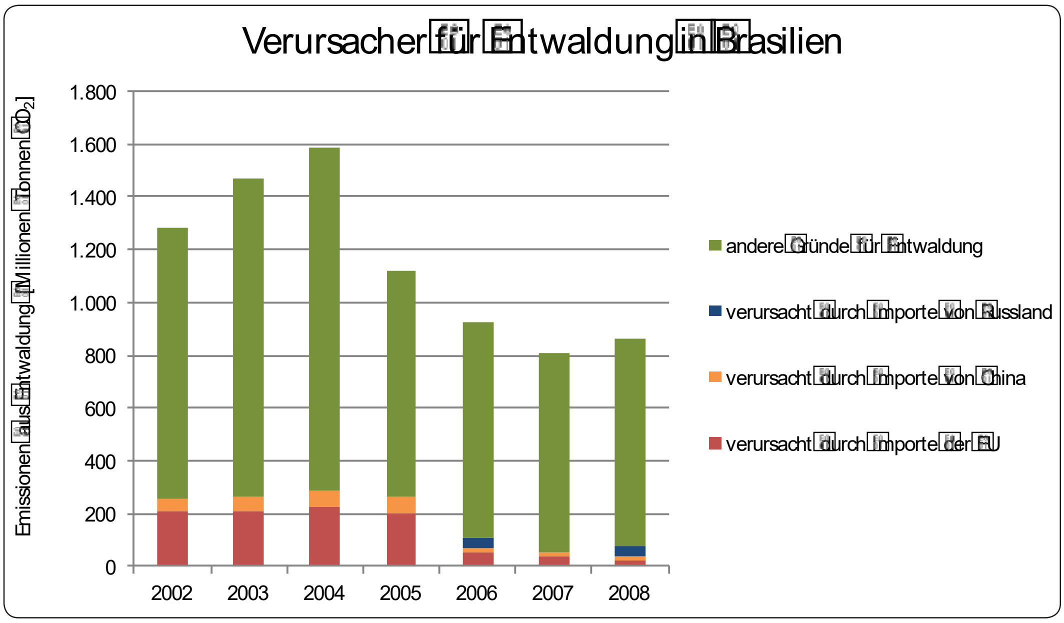


Abbildung 1: Ergebnisse der Verknüpfung der brasilianischen Emissionen aus Entwaldung mit den Importen von Soja und Rindfleisch durch die EU, China und Russland zwischen 2002 und 2008, eigene Darstellung und Berechnungen.

Soja – das bedeutendste Importgut der EU für die Entwaldung in Brasilien

Drei Viertel der durch die EU verursachten Entwaldungsemissionen entstehen durch Sojaplantagen, wohingegen Entwaldung auf Grund von Rinderweiden nur ein Viertel ausmacht. Diese Verteilung ergibt sich durch die Einbeziehung von iLUC, welche in vielen anderen Studien nicht quantifiziert wird, was zu einer Unterschätzung des Einflusses von Soja führt. Da in der Literatur eine systematische Übernahme von Weiden durch Sojaplantagen nach durchschnittlich acht Jahren beschrieben wird (Macedo et al., 2012), konnten die mit iLUC verbundenen Entwaldungsemissionen berechnet und statt Rindfleisch Soja zugeordnet werden.

Die vorliegende Studie zeigt, dass die EU zwischen 2002 – 2008 einer der Hauptverursacher für Entwaldung in Brasilien war. Aktuellere Studien, z.B. die der Europäischen Kommission, bestätigen diese Ergebnisse (European Commission, 2013).

Aktuelle Entwicklungen: Verbesserungen aber keine Entwarnung

Als die vorliegende Studie geschrieben wurde, waren Daten, besonders zur Entwaldung in der Cerrado, nur bis 2008 verfügbar. Um die Ergebnisse in die aktuellen Entwicklungen einzuordnen, wurde diese Zusammenfassung erweitert und komplett aktualisiert.

Entwaldung: Stagnation auf niedrigerem Niveau

Zunächst wollen wir einen Blick auf die Entwaldung werfen. Wie in Abbildung 2 gezeigt, war die Entwaldung im Amazonasgebiet in den letzten Jahren recht konstant bei 5.000 – 6.000 km^2. Das entspricht nur ungefähr einem Fünftel der Fläche, die noch 2004 entwaldet wurde, ist jedoch trotzdem doppelt so groß wie das Saarland.

Die Quantifizierung der Entwaldung in der Cerrado stellt immer noch ein Problem dar, da es noch keine guten Satellitenüberwachungssysteme gibt. Daher gibt es neben der Information über die durchschnittliche Entwaldung zwischen 2002 und 2008 nur Daten bis 2010. Die Entwaldung in der Cerrado scheint enorm abgenommen zu haben, auf ca. 7.000 km^2 pro Jahr.

Trotz dieser Reduktion hat Brasilien in absoluten Zahlen immer noch die höchste Entwaldungsrate der Welt (FAO, 2015). Ein Hotspot der Entwaldung, der in dieser Studie nicht betrachtet wurde, ist

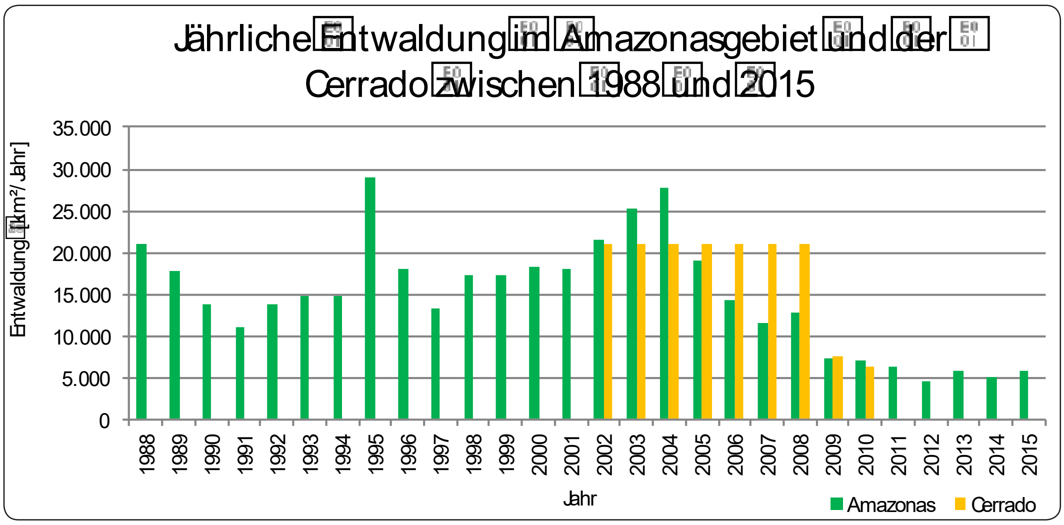


Abbildung 2: Entwicklung der Entwaldung im Amazonasgebiet und der Cerrado. Eigene Darstellung, Daten von INPE, Brazilian Government (2009) and Portal Brazil (2012).

der Atlantische Regenwald, welcher ebenfalls extreme Entwaldung auf Grund des Anbaus von Soja erlebt (WWF, 2014).

Waren die initiierten Maßnahmen erfolgreich?

Der Rückgang der Entwaldung im Amazonas und der Cerrado zeigt, dass manche der Maßnahmen gegen Entwaldung effektiv waren. Diese umfassen unter anderem die verbesserte Durchsetzung von Gesetzen, das Soja Moratorium, das im Mai 2016 auf unbestimmte Zeit verlängert wurde, den „Forest Code", Restriktionen zum Erhalt von landwirtschaftlichen Krediten für Landwirte in von Entwaldung betroffenen Landkreisen, Satellitenüberwachung, die Ausweitung der Schutzflächen und die Restaurierung degradierter Flächen.

Für die kommenden Jahre ist es jedoch nicht garantiert, dass dieser Erfolg anhält: Der neue „Forest Code" gewährt eine Amnestie für illegale Entwaldung, die vor 2008 stattfand, und sein Mechanismus für den Handel mit Entwaldungsrechten wird sehr kontrovers diskutiert. Zudem wurde die Fläche einiger Schutzgebiete reduziert (Gibbs et al., 2015; Soares-Filho et al., 2014).

Lassen Sie uns einen Blick auf die Entwicklungen im Amazonasgebiet der letzten Jahre werfen: Die Sojaproduktion nahm zwischen 2007 und 2012 stark zu, wohingegen die Rindfleischproduktion seit 2008 mehr oder weniger stagniert. Gleichzeitig wurde die Rindfleischproduktion intensiviert, so dass die Anzahl der Rinder pro Fläche zunahm. Dies führte zu einem Überschuss an Rinderweiden, die dann als Sojaanbauflächen genutzt wurden. Daraus resultierte die gesunkene Entwaldung (Nepstad et al., 2014).

Rinderhaltung und Sojaanbau verlagern sich immer mehr in die Cerrado. Dort werden ca. 70 % der landwirtschaftlichen Erzeugnisse Brasiliens hergestellt (Pearce, 2011), weil das Sojamoratorium für dieses Gebiet nicht gilt, es keine so guten Satellitenüberwachungssysteme gibt etc. (Nepstad et al., 2014). Laut NASA (2015) hat das Sojamoratorium im Amazonasgebiet sogar dazu geführt, dass sich die Entwaldung in den letzten Jahren in die Cerrado verlagert hat.

Ein weiterer Grund, warum die Cerrado anfälliger für Entwaldung ist, resultiert daraus, dass nur 8,24 % (168.000 km^2) der Cerrado offiziell geschützt sind und nur ⅓ dieser Fläche als strikte Schutzzone (protection area, PA) ausgewiesen ist. Françoso et al. (2015) verglichen die Entwaldungsraten der unterschiedlichen Schutzzonen und fanden heraus, dass sich die Entwaldungsraten in speziell ausgewiesenen PAs zur nachhaltigen Nutzung nicht von denen außerhalb der PAs unterschieden. Nur die Entwaldungsraten in den strikten PAs waren bedeutend geringer.

Ausblick: Die Zukunft des Amazonas und der Cerrado ist völlig unklar

Wird Brasilien seine Ziele zur Reduzierung der Entwaldung erreichen und diese, auch in der Cerrado, niedrig halten können? Nepstad et al. (2014) sind sich nicht sicher, ob die verstärkte Durchsetzung der Gesetze und ökonomische Anreize genügen und weisen darauf hin, dass es immer noch 120.000 km² Waldfläche außerhalb der PAs im brasilianischen Amazonasgebiet gibt, die sich finanziell für eine Umwandlung in Sojaplantagen lohnt.

Die brasilianische Regierung entwirft verschiedene Zukunftsszenarien für das Amazonasgebiet. Als Basis für das brasilianische INDC (Intended Nationally Determined Contribution), welches im Vorfeld der COP21 in Paris im Jahr 2015 erarbeitet wurde, entwickelte INPE (The Brazilian National Institute for Space Research) drei Szenarien. Sie reichen von einem optimistischen Szenario mit Restauration und Schutzmaßnahmen, die die im „Forest Code" vorgesehenen Maßnahmen übertreffen, bis zu einem pessimistischen Szenario, in welchem die ökologischen Errungenschaften der vergangenen Jahre rückgängig gemacht werden. Im optimistischen Szenario, in welchem Kahlschlag und Degradierung von bewaldeten Flächen gestoppt werden und die sekundäre Vegetation zunimmt, wird der Amazonas nach 2020 zu einer Kohlenstoffsenke. Im pessimistischen Szenario steigen die Entwaldungsraten wieder an, zudem nehmen andere Probleme, wie die ungeordnete Urbanisierung, weiter zu.

Aktuelle Zahlen zu Produktion und Handel von Soja und Rindfleisch

Zwischen 2010 und 2014 ist die Sojaanbaufläche in Brasilien um 30 % gewachsen, damit umfasste sie im Jahr 2014 die Fläche Italiens (mehr als 30 Millionen ha) und nahm 40 % der brasilianischen Ackerfläche ein. 9 / 10 der weltweiten Sojabohnenexporte stammen aus den Vereinigten Staaten von Amerika, Argentinien und Brasilien (WWF, 2014). Seit 2010 sind die brasilianischen Exporte um fast 50 % gestiegen. Auch die Rindfleischexporte aus Brasilien sind stark gestiegen: Zwischen 2010 und 2013 um 24 % (FAOSTAT und UN Comtrade).

Aktuelle Zahlen zu Soja- und Rindfleischimporten der EU

Betrachtet man die Importe, zeigen sich unterschiedliche Entwicklungen für Soja und Rindfleisch. Während die Sojaimporte in die EU zwischen 2010 und 2014 um ungefähr 10 % zurückgingen, stiegen die Rindfleischimporte um fast 60 % an. Für beide Handelsgüter bleibt Brasilien der wichtigste Handelspartner der EU.

Was Soja anbetrifft, haben von den anderen wichtigen südamerikanischen Exporteuren Paraguay und Uruguay ihre Anbaufläche und die weltweiten Exporte stark erhöht. Damit einhergehend hat die EU ihre Importe aus diesen beiden Ländern zwischen 2005 und 2010 ebenfalls drastisch erhöht (+482 % aus Uruguay und +173 % aus Paraguay, Daten von UN Comtrade). Im Zuge der rückläufigen europäischen Sojaimporte der letzten Jahre sind diese seit 2010 ebenfalls zurückgegangen. Die Zahlen lassen schlussfolgern, dass die EU in Bezug auf Soja nicht mehr der Hauptverursacher für die Ausdehnung von Ackerland ist. China ist mittlerweile mit Abstand der größte Sojaimporteur.

In Bezug auf Rindfleisch sind Uruguay und Argentinien neben Brasilien die Haupthandelspartner der EU. Deren Rindfleischexporte sind in den letzten Jahren jedoch mehr oder weniger konstant bis rückläufig. In Anbetracht der steigenden Rindfleischimporte aus Brasilien nimmt der Einfluss der EU auf die Entwaldung hingegen erneut zu.

Vielschichtiges Bild

Die Analyse der aktuellen Entwicklungen zeigt ein vielschichtiges Bild. Auf der einen Seite wurde die Entwaldung beträchtlich reduziert, auf der anderen Seite gibt es keine Informationen zu den derzeitigen Entwaldungsraten für die Cerrado. Zudem scheint der „Forest Code", der den Wald schützen soll, vielmehr zur Entwaldung in der Cerrado beizutragen. Des Weiteren garantieren Schutzgebiete keinen Schutz vor Entwaldung. Außerdem expandieren Sojaanbauflächen und Rinderweiden immer noch auf bewaldete Flächen oder ehemalige Weiden und die brasilianische Wirtschaft ist stark vom Export dieser Handelswaren abhängig. Die EU trägt unverändert zur Entwaldung in Brasilien bei und muss daher nach Möglichkeiten suchen, diese zu reduzieren.

(Politische) Schlussfolgerungen

Die Schlussfolgerungen dieser Studie setzen auf drei verschiedenen Ebenen an. Zuerst sollte die Entwaldung in Brasilien durch angemessene Maßnahmen reduziert werden. Dies sind die effektive Anwendung der geltenden Gesetze, ambitioniertere Ziele für die Entwaldungsreduktion, eine Vergrößerung der strengen Schutzgebiete und der Aufbau eines effektiven Echtzeit-Überwachsungssystems für Entwaldung, das auch andere Biome außerhalb des Amazonas abdeckt. Des Weiteren sollte die Ausdehnung der landwirtschaftlichen Fläche auf brach liegenden und degradierten Rinderweiden unterstützt werden. Verlagerung auf andere Flächen und iLUC können verhindert werden, indem statt dezentraler Entwaldungsziele unterschiedlicher Biome nationale Ziele definiert werden, durch eine engere Zusammenarbeit der Sektoren für Rindfleisch, Soja und Biokraftstoffe sowie durch partizipativere Prozesse. Zudem sollten verlässlichere, Transparenz schaffende Instrumente die Einhaltung der freiwilligen Vereinbarungen wie dem RTRS (Round Table on Responsible Soy) sicherstellen.

Zweitens sollte die EU ihren negativen Einfluss auf die Entwaldung in Brasilien reduzieren. Dies kann erreicht werden, indem die Produktion von zertifizierten entwaldungsfreien Produkten durch entsprechende Nachfrage und Importe unterstützt wird. Für andere Importgüter wie Biokraftstoffe gibt es mit der Erneuerbare-Energien-Richtlinie bereits gute Regelungen für Nachhaltigkeitsstandards. Das Partnerschaftsabkommen FLEGT für den Holzhandel ist ein anderes gutes Beispiel, das auf Soja, Rindfleisch und andere Handelsgüter übertragen werden könnte. Folglich müssten die importierten Produkte gewisse Nachhaltigkeitsstandards erfüllen, gleichzeitig müsste die EU die Exportländer unterstützen, diese zu erreichen.

Außerdem sollte sich die EU selbst weitreichendere Nachhaltigkeitsziele setzen, die auch die Reduktion virtueller Landnutzung – und damit Entwaldungsemissionen im Ausland – beinhalten. Durch ein solches Ziel könnten zudem der Pestizidverbrauch, Landkonflikte mit der lokalen Bevölkerung, Landdegradierung und andere Probleme in den exportierenden Ländern reduziert werden. Verbunden mit der Reduktion der virtuellen Landnutzung ist die Erhöhung der Selbstversorgungsrate der EU mit proteinreichem Tierfutter. Die Förderung dieser Leguminosen, die zudem gut für die Stickstoffanreicherung im Boden sind, wird bereits mit der „Europäischen Eiweißstrategie“ vorangetrieben. Trotzdem sind entschiedenere Aktivitäten notwendig, was die Forschung, Züchtung geeigneter und angepasster Sorten, Beratung sowie Schulungen angeht.

Die Strategie der EU sollte außerdem die Reduktion der Fleischproduktion und des Fleischkonsums beinhalten. Die Fleischproduktion der EU hängt nicht nur von der lokalen Nachfrage, sondern auch zu großen Teilen von Exporten, vor allem nach Afrika, ab. Dort werden als Konsequenz unter anderem lokale Märkte zerstört. Daher sollten alle Anreize, die den Export von Fleisch fördern, beseitigt werden. Zudem könnte eine Bewusstseinskampagne in der EU für eine gesunde Ernährung mit weniger Fleisch den Fleischverzehr senken.

Drittens sollten alle Staaten die Beendigung von Entwaldung mehr in ihre Bemühungen zum Klimaschutz einbeziehen und Instrumente zur Bekämpfung der Entwaldung wie REDDplus stärken. Außerdem könnte durch eine Internalisierung der Umweltkosten ein Rückgang der weltweiten Entwaldung erreicht werden, zum Beispiel durch eine CO_2-Steuer. Zudem erscheint es als sehr wichtig, mehr auf konsumbasierte Treibhausgasbilanzierung zu setzen und Kräfte und finanzielle Mittel zu bündeln, um nachfrageverursachte Emissionen zu reduzieren. Hierfür müssen die virtuelle Landnutzung und die damit verbundenen Emissionen quantifiziert werden, wie es die vorliegende Studie oder die Europäische Kommission (2013) zeigen. Dann können die Emissionen gemeinsam von den konsumierenden und den produzierenden Ländern effektiv gesenkt werden.

Berechnungsmethoden und -schritte

In den folgenden drei Abbildungen sind alle Berechnungsschritte, die in dieser Studie genutzt wurden, dargestellt.

Zunächst wurde die direkte Landnutzungsänderung (dLUC) durch die Angaben zu Fläche und Emissionen und / oder Emissionsfaktoren für den Amazonas und die Cerrado berechnet. Diese Entwaldungsemissionen wurden dann – getrennt für die beiden Biome – auf der Grundlage von Literaturangaben auf die Umwandlung von Wald in Sojafelder bzw. von Wald in Rinderweiden aufgeteilt. Die direkten Entwaldungsemissionen der EU ergeben sich aus der Multiplikation dieser Ergebnisse mit dem Anteil der Handelswaren, die in die EU exportiert werden (siehe Abbildung 3).

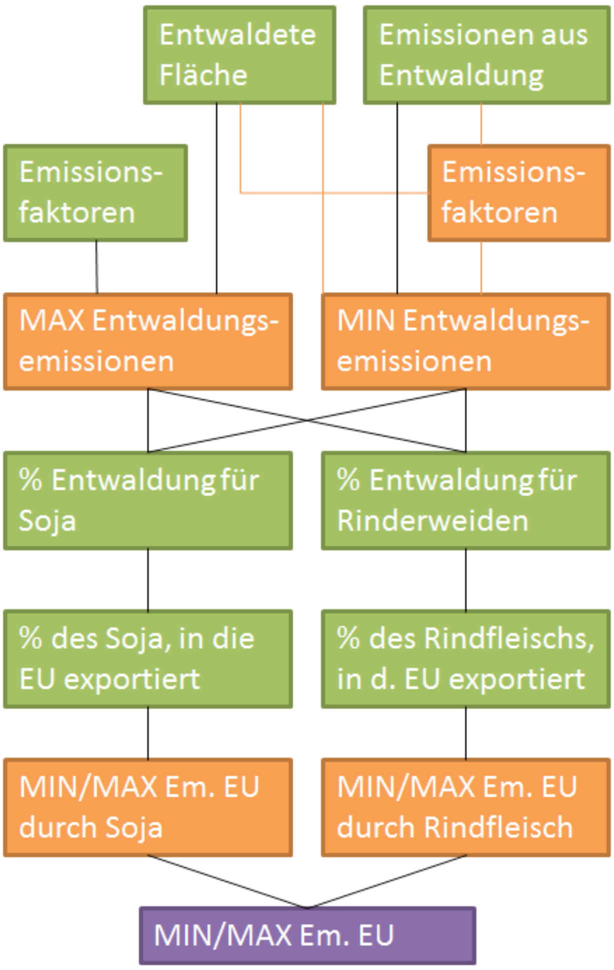


Abbildung 3: Emissionen aus direkter Landnutzungsänderung – Berechnungsschritte.

Farbschema:
Grün = Daten aus der Literatur
Orange = berechnet;
Violett = Ergebnis

Hinweise:
(1) Für den Amazonas und die Cerrado wurde dieselbe Methode angewandt.
(2) In der Literatur war keine komplette Zeitreihe für Entwaldungsemissionen zu finden. Daher wurden die Emissionen für die fehlenden Jahre durch berechnete implizite Emissionsfaktoren aus vergangenen oder zukünftigen Jahren und der entwaldeten Fläche ermittelt (orange Linien).

Um die Emissionen aus indirekter Landnutzungsänderung zu berechnen, wurden Daten aus der Literatur zur Sojaanbaufläche, zum Anteil der Sojafelder, die auf Rinderweiden entstehen, und zu den durchschnittlichen Umwandlungsmustern genutzt. Zum einen kann damit die Fläche berechnet werden, die zunächst als Rinderweide, dann als Sojafeld dient, zum anderen kann dadurch nachvollzogen werden, wie die Umwandlung von Rinderweiden zu Sojafeldern zeitlich verläuft (siehe Abbildung 4).

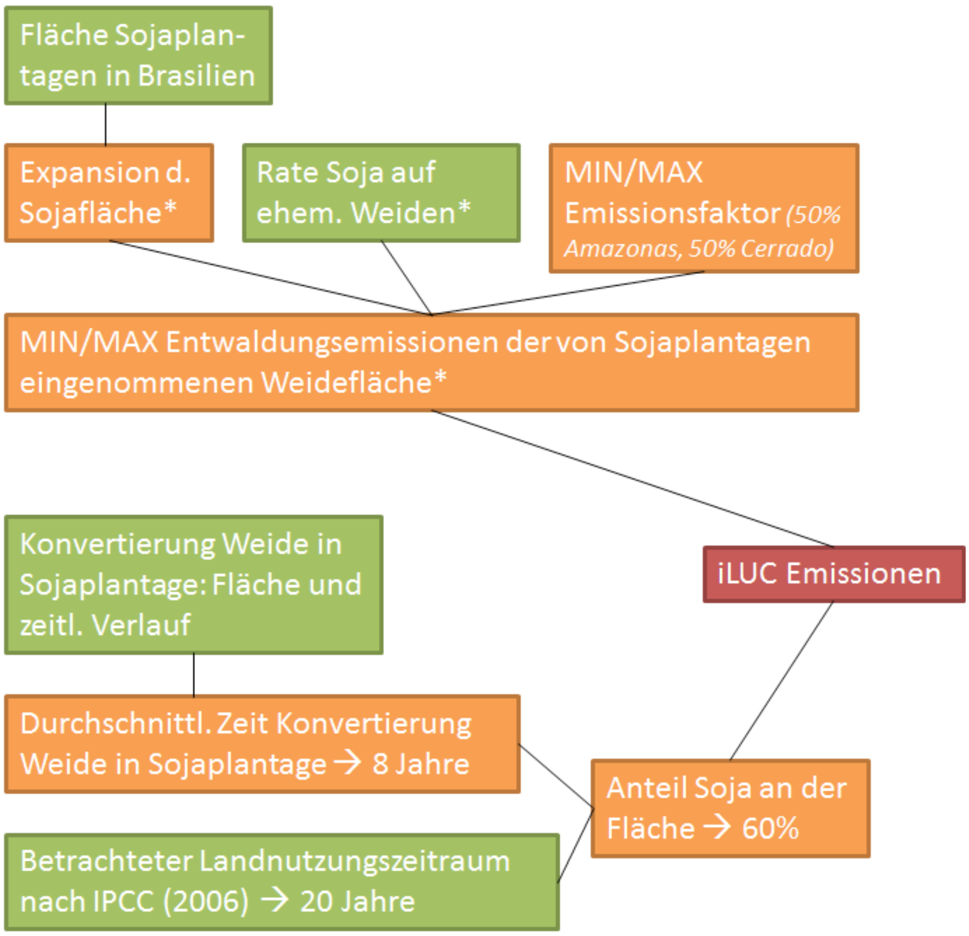


Abbildung 4: Emissionen aus indirekter Landnutzungsänderung – Berechnungsschritt 1.

Farbschema:
Grün = Daten aus der Literatur
Orange = berechnet
Rot = Ergebnis indirekte Landnutzungsänderung

*** Differenzierung zwischen den Zeiträumen 2011–2005 und 2006–2010.**

In einem zweiten Schritt wurden diese Emissionen aus iLUC neu zwischen Rindfleisch und Soja verteilt. Die sich daraus ergebenden Emissionen wurden erneut mit den Anteilen, die die EU am Export hat, multipliziert, um schlussendlich die Emissionen aus der Entwaldung – inklusive iLUC – zu erhalten, die die EU durch ihren Import von Rindfleisch und Soja aus Brasilien verursacht (siehe Abbildung 5).

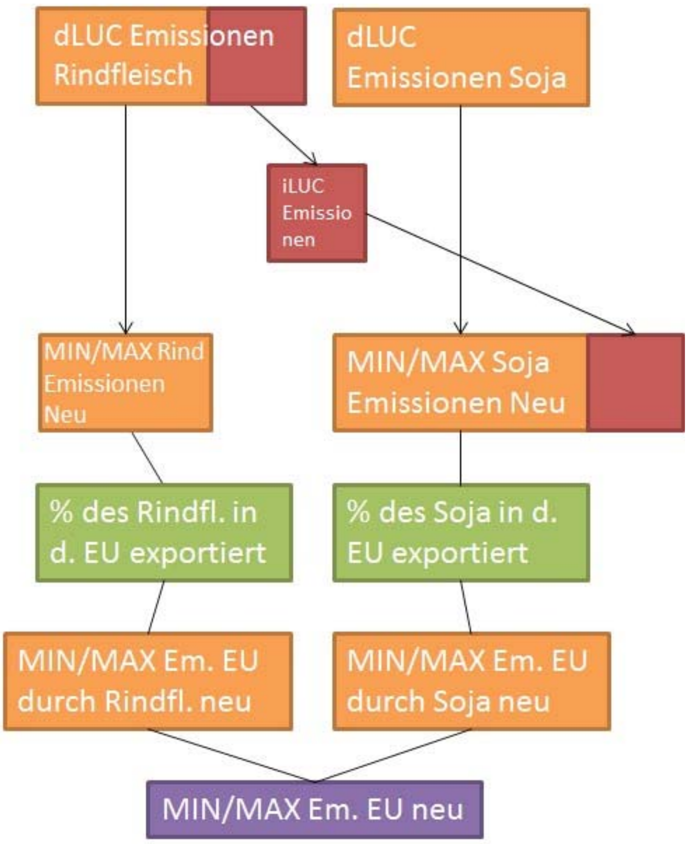


Abbildung 5: Emissionen aus indirekter Landnutzungsänderung – Berechnungsschritt 2.

Farbschema:
Grün = Daten aus der Literatur
Orange = berechnet
Rot = Ergebnis indirekte Landnutzungsänderung
Violett = Gesamtergebnis

Table of Contents

List of Figures

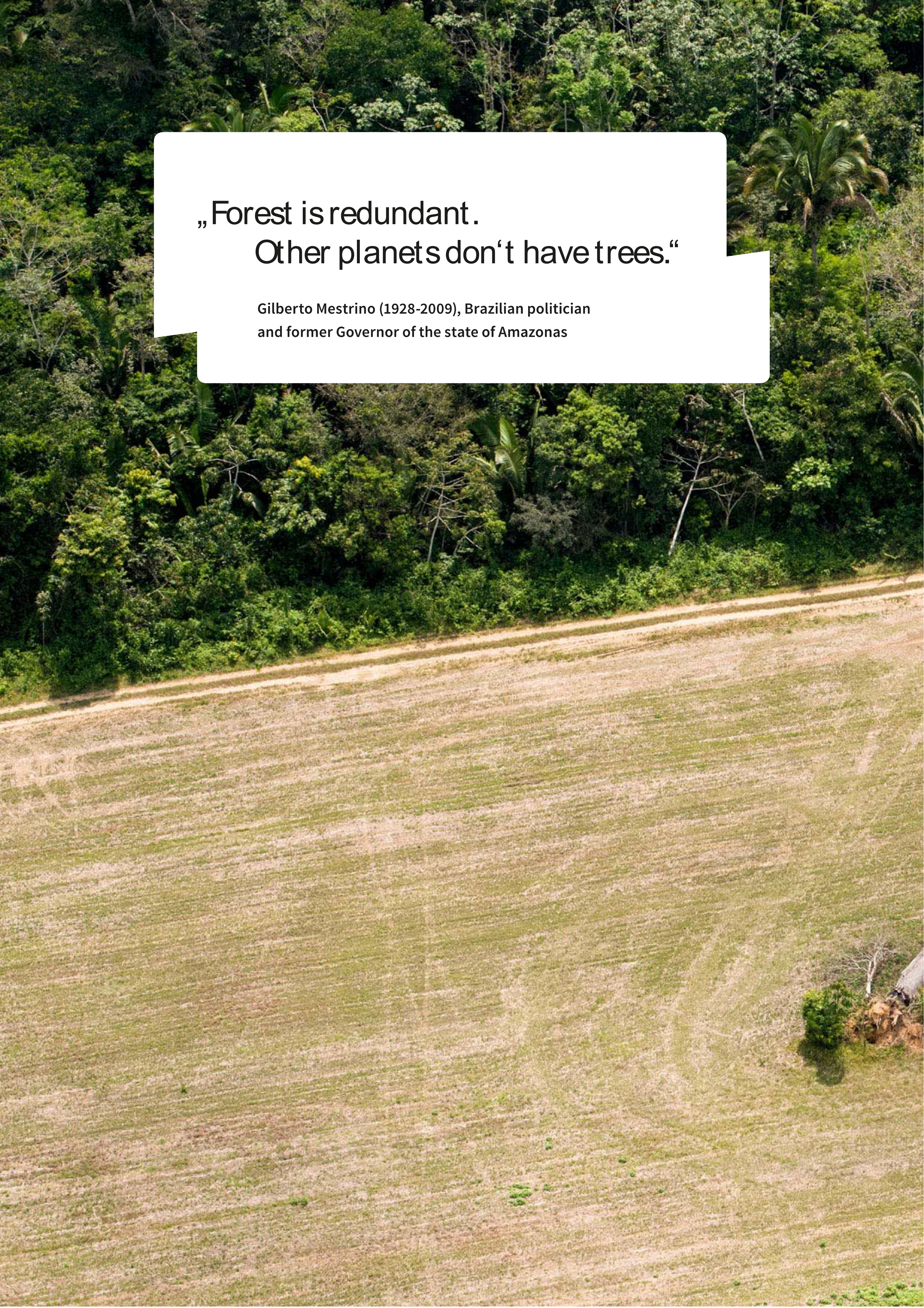
List of Tables

List of Equations

Photo Credits

List of Acronyms and Abbreviations

BSE	Bovine Spongiform Encephalopathy
CAP	Common Agricultural Policy of the EU
CO_2	Carbon Dioxide
COP	Conference of the Parties
ETS	Emissions Trading System
FAO	Food and Agriculture Organization of the United Nations
FC	Forest Code
FLEGT	Forest Law Enforcement, Governance and Trade
FMD	Foot-and-Mouth Disease
GHG	Greenhouse Gas
ha	Hectares
iLUC	Indirect Land Use Change
INDC	Intended Nationally Determined Contributions
INPE	The Brazilian National Institute for Space Research
IPCC	International Panel on Climate Change
NGO	Non-governmental Organisation
REDDplus	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of carbon stocks in developing countries
RTRS	Round Table on Responsible Soy
UNFCCC	United Nations Framework Convention on Climate Change



„Forest is redundant.
Other planets don‘t have trees.“

Gilberto Mestrino (1928-2009), Brazilian politician
and former Governor of the state of Amazonas

1 Introduction

In the following introduction, the frame of the study will be set. This includes the problem description and the theoretical framework as well as the research approach. Then Brazil, the study area, is introduced and the rationales for choosing the EU as well as cattle meat and soya exports are explained.

1.1 Problem Description and Theoretical Framework

Deforestation is a huge environmental and socio-economic problem. The impacts of deforestation include emissions of carbon dioxide that was stored in the forest biomass and in the soil, emissions of other greenhouse gases (GHGs), a loss of biodiversity, species extinction, habitat fragmentation, a decrease in fresh water availability, land degradation, soil loss and a change in local climate towards less precipitation and higher temperatures. Chomitz & Thomas (2001) state that "clearing is [as well] associated with large-scale runaway fires" (p. 14). Furthermore, deforestation leads to the loss of habitat of people living in the forest, to the loss of a culturally important ecosystem for locals as well as tourists and to the loss of economically important forest ecosystem services like the provision of food, firewood and medicines (WWF UK, 2011; von Witzke et al., 2011; Greenpeace, 2006; Ibrahim et al., 2010; Klink & Moreira, 2002; Gottwald & Fischler, 2007).

1.1.1 Extent of Deforestation and its Relevance for Climate Change

The worldwide average annual deforestation between the years 2000 and 2010 was more than nine million hectares (own calculation, data from FAO, 2010, p. 18), the German Advisory Council on Global Change (WBGU) (2011) states it may have been 13 million hectares with 44 % of that, or nearly four million hectares annually, deforested in South America alone (FAO, 2010; see Figure 6).

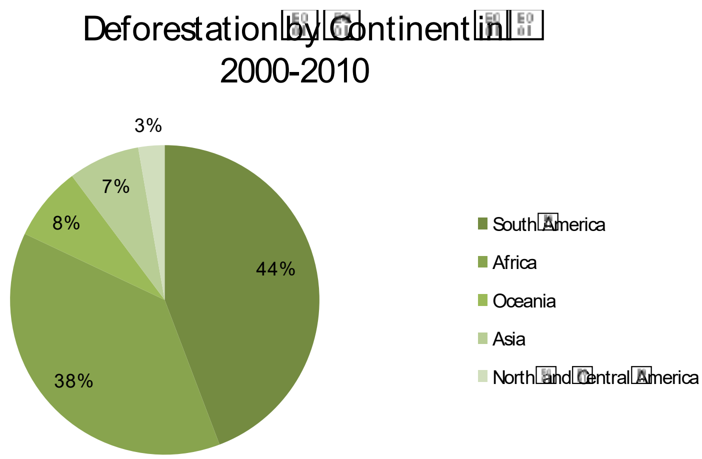


Figure 6: Distribution of Total Deforestation between the Continents from 2000 to 2010 (own figure, data from FAO, 2010)

Brazil has the largest loss of forest area in absolute numbers in the world (see also Figure 7). Between 2000 and 2010 the net loss of forest in Brazil was more than 2,6 million hectares annually (FAO, 2010). This means that 29 % of total deforestation worldwide between 2000 and 2010 happened in Brazil (own calculation, data from FAO, 2010) – between 2000 and 2005 it was 42 % (Ibrahim et al., 2010).

Australia has had the second highest deforestation between the years 2005 – 2010 with a bit more than 900,000 hectares. The very high forest loss in Australia was caused by severe droughts and forest fires. In contrast, forest fires only play a very minor role for forest loss in South America (FAO, 2010).

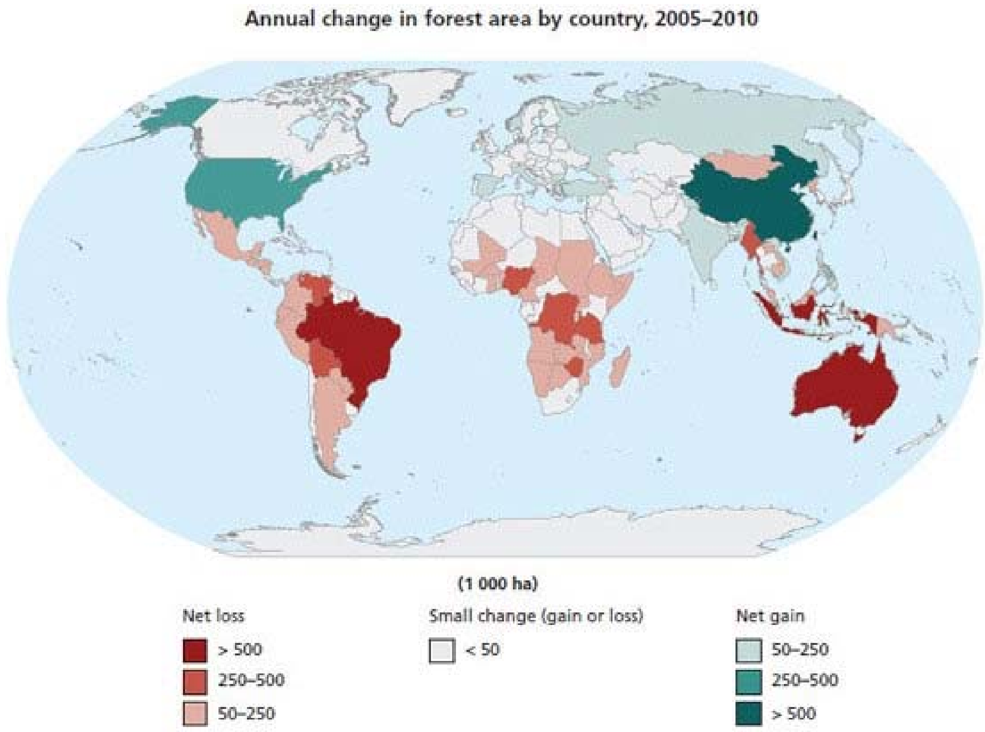


Figure 7: Annual Change in Forest Area by Country between 2005 and 2010 (FAO, 2010, p. XVII, reproduced with permission from FAO)

Due to the fact that more than 70 % of South America's forest is primary forest – this is by far the largest share of primary forest per continent worldwide – and that even 92 % of Brazil's forest is primary forest, most of the forest area lost is ecologically important and species-rich. In Brazil, 2,5 million hectares, or 95 % out of the 2,642 million hectares of the annually lost forest area, is primary forest (FAO, 2010).

This deforestation causes CO_2-emissions that lead to global warming and climate change. And the share of GHGs coming from deforestation must not be underestimated: globally, more than 17 % of all GHG-emissions come from the forestry sector (see Figure 8) which includes CO_2-emissions from deforestation, from decay, and from peat soils (IPCC, 2007). From deforestation and harmful forest use alone, the annual emissions between 2000 and 2009 are estimated to be between 2.6 and 4 gigatons of CO_2 (WBGU, 2011) – more than the EU's total annual GHG-emissions. So deforestation is very relevant for climate change and measures to halt it are quite important for successful climate change mitigation.

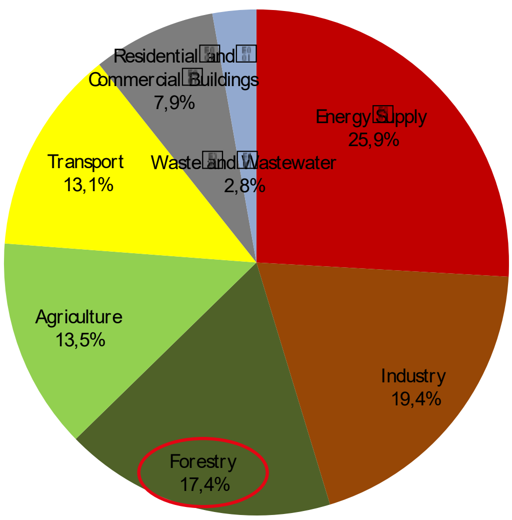


Figure 8: Global Greenhouse Gas Emissions by Sector (own figure, data from IPCC, 2007, p. 36)

In Brazil, the CO_2-emissions from land use change and forestry added up to more than 1,26 gigatons in 2005, which accounted for 77 % of the country's total CO_2-emissions, or 61 % of its GHG-emissions. Around 90 % of these CO_2-emissions can be attributed to deforestation in the Amazon and the Cerrado (MCT Brazil, 2010). So for Brazil, the emissions from deforestation play the major role in their GHG inventory.

In this study, just the CO_2-emissions and no other negative effects associated with deforestation, such as social, cultural, or economic, are considered further.

1.1.2 Drivers of Deforestation and the Role of the EU

The WBGU mentions the increasing competition for land as one of five megatrends in its study “World in Transition – A Social Contract for Sustainability” (2011). This competition for land is quite relevant in Brazil because the areas for sugar cane, used for biofuel, as well as for cattle pastures and soya, used for animal feed and oil, has been growing in the past and is predicted to grow in the future, putting increased pressure on Brazil’s native ecosystems (von Witzke et al., 2011).

Geist & Lambin (2001) analysed the proximate and underlying drivers of deforestation in the tropics in their study; in Figure 9 the results of their meta-analysis can be seen. It can be derived from this figure that across all countries in Asia, Africa, and Latin America, agricultural expansion is most often linked directly to deforestation, mainly associated with wood extraction and infrastructure extension.

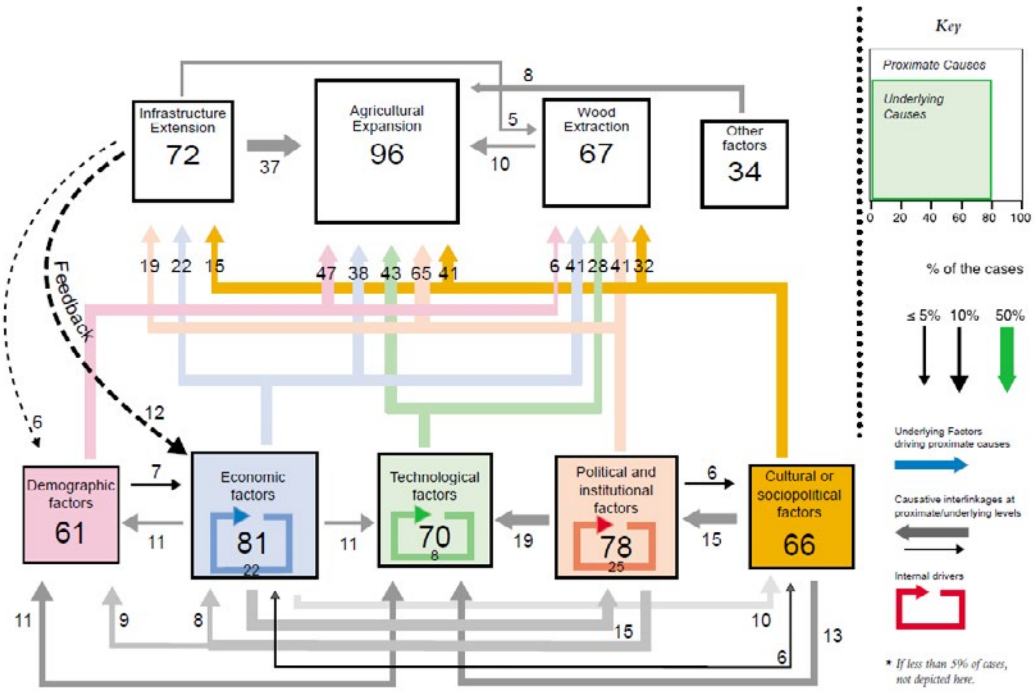


Figure 9: Proximate and Underlying Causes of Deforestation in Tropical Countries and their Interconnections (Geist & Lambin, 2001, p. 85, reproduced with permission from Oxford University Press / Bioscience)

Agricultural Drivers

Animal products have a much larger need for land than plant-based food, as 70 % of all arable land in the world is used for pasture and the production of animal feed (WBGU, 2011; HBS et al., 2013). The share of land used for animal products and feed is anticipated to increase as well (von Witzke et al., 2011).

Ermolieva et al. (2012) approve the finding of Geist & Lambin (2001) and state that between 1990 and 2008, 127 million hectares of deforestation were caused from agricultural expansion worldwide. In Figure 10, the extents of deforestation and the sectors responsible for it are shown for different regions. As can be seen, the livestock sector is the most important and the crop sector is the second most important driver of deforestation in South America. In Figure 11 it can furthermore be seen that in South America, soya is the most responsible for deforestation among the crops.

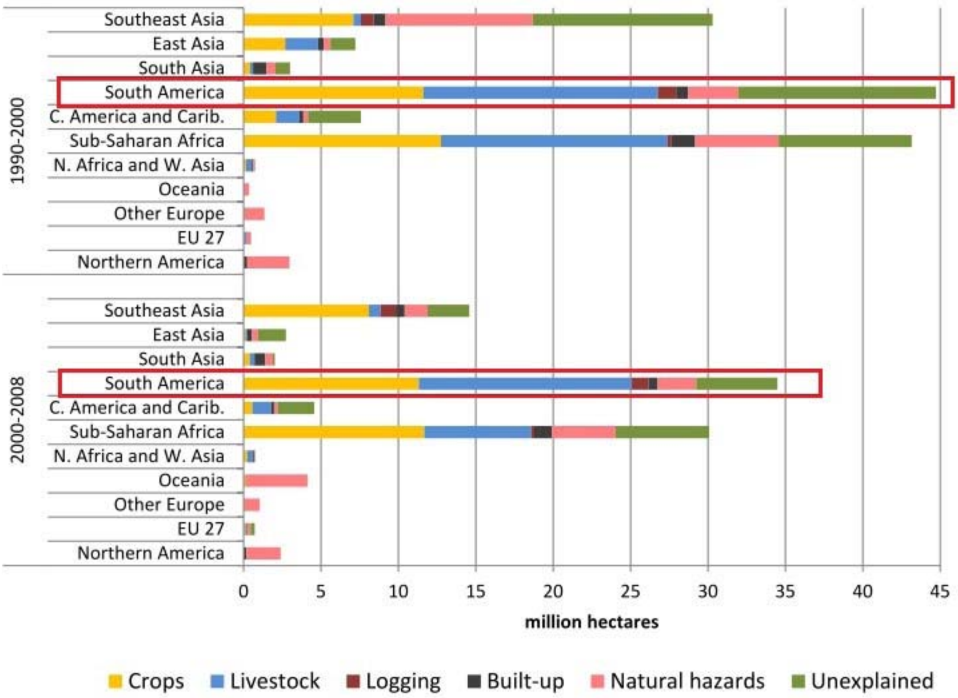


Figure 10: Extent of Deforestation and Responsible Sectors in Different Regions, Cumulative Values for the Period Between 1990 until 2008 (Ermolieva *et al.*, 2012, p. 83, reproduced with permission from the International Institute for Applied Systems Analysis (IIASA))

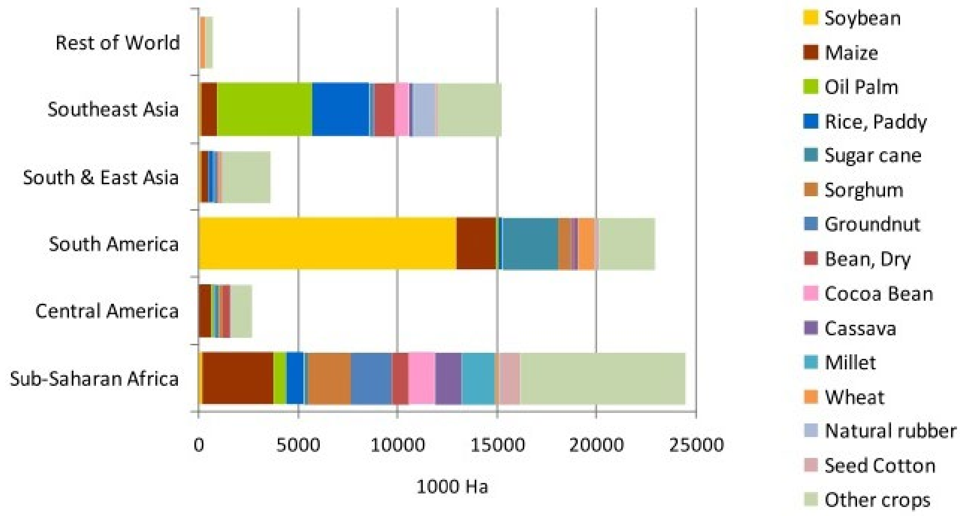


Figure 11: Share of Crops in Deforestation: Soybean as the Most Important Crop Causing Deforestation in South America, Period: 1990 – 2008 (Ermolieva *et al.*, 2012, p.83, reproduced with permission from the International Institute for Applied Systems Analysis (IIASA))

Also for Brazil, a lot of studies identified agricultural land uses, especially cattle ranching and soya plantations, as the main drivers of deforestation (e.g. Boucher *et al.*, 2011; Kissinger *et al.*, 2012; Alves *et al.*, 2009; Greenpeace 2009a and b; Chomitz & Thomas, 2001; Macedo *et al.*, 2012; WHRC, 2013; von Witzke *et al.*, 2011; Ibrahim *et al.*, 2010; Margulis, 2004), this is why this study looks at these two commodities. More details on them are given in chapter 1.5 below.

Sugar cane is, however, not contributing much to deforestation among the agricultural drivers because nearly most of it is grown on previously converted cropland and pastures. This is due to the fact that sugar cane needs better prepared soil to grow properly than pastures or soya plantations (Moreira, 2011).

Timber Extraction as a Driver

Timber extraction is more a driver of degradation than deforestation (Kissinger et al., 2012). Moreover, it has been found out that if land is cleared for pasture, the timber is often sold to finance the pasture which makes pastures on just deforested areas quite profitable. So logging for timber might in many cases not be the real driver of deforestation but is only a step before the establishment of a pasture (e.g. HBS et al., 2013; Ibrahim et al., 2010).

Infrastructure Driving Deforestation

Infrastructure is often the starting point or accelerating aspect for deforestation – this is called the "dragging effect" – and thus more of an underlying driver. In Brazil, several state programmes like "Brazil in Action" from 1996 – 1999, have supported soya infrastructure in the Amazon, for example ports and roads, which then led to an increase in soya plantations and deforestation (Fearnside, 2001; Nepstad et al., 2006a; Nepstad et al., 2006b; Ibrahim et al., 2010; Nellemann & INTERPOL, 2012). This infrastructure which is needed to transport harvested soya beans, lime and fertiliser makes the impact of soya on the environment even larger (Fearnside, 2001).

Political Factors

Land tenure in Brazil can be obtained when land is used. This is why many people went into the Amazon and established pastures there, which is the cheapest way of using land in Brazil (Fearnside, 2001; Ibrahim et al., 2010; Macedo et al., 2012). Land is much cheaper there so people often sell their land elsewhere to go into the Amazon (Fearnside, 2001). Settlements in the Amazon and agricultural activities there were promoted by the government in the 1970s "to ensure territorial sovereignty" and later for the development of the region because it should be integrated into the socio-economic system of Brazil (MCT Brazil, 2010, p. 348). So population growth due to these political decisions was the main underlying driver of deforestation during that time period.

Brazilian state subsidies in the form of free fertilisers and lime to make the Amazon and Cerrado soil suitable for soya plantations have made the soya there cheaper to grow than elsewhere and have therefore been an important underlying driver of deforestation in the past. The cultivation of the Cerrado started with agricultural research on improving the soil. In the late 1990s, the expansion of soya plantations into the Amazon was related to the development of soya species that were adapted to the Amazonian climate (Fearnside, 2001; Klink & Moreira, 2002; Nepstad et al., 2008).

Other subsidies that promoted agricultural expansion in the past were subsidised credits, low taxes on property in the Amazon, a minimum price guarantee for soya no matter where it is planted and a unified price for fuel which made it cheaper to transport soya from remote locations to the processing and exporting facilities (Fearnside, 2001; Ibrahim et al., 2010; Klink & Moreira, 2002; MCT Brazil, 2010).

Economic Drivers

In the last couple of years, economic factors have become more important as underlying drivers of deforestation with the political factors becoming less so (Ibrahim et al., 2010). International market forces have been identified as drivers of deforestation by Nepstad et al. (2006a) and others, who call this 'economic teleconnections', (see Figure 12). The economic growth of China seems to be quite important as well as the demand for open range meat as a consequence of the BSE crisis in Europe. Other animal pests like foot-and-mouth disease drive deforestation while the avian flu lowers the demand for soya. Another important aspect is the value of the Brazilian currency, the Real. When there was devaluation, there was more export of soya and cattle meat (Nepstad et al., 2006a).

DeFries et al. (2010) found out that the demand of the increasing urban population is responsible for tropical deforestation because large machinery and plantations are used to fulfil this demand. In contrast to that, the rural population growth, subsistence farming and firewood collection has not been found to correlate with deforestation in tropical countries in the first half of the last decade (DeFries et al., 2010). If the projections of the United Nations saying that by 2050 nearly two thirds of the total population will be living in cities, this driver will become even stronger in the future.

As Fearnside (2001) states, these market forces are especially important drivers of the expansion of soya plantations which distinguishes soya from other crops. The expansion of soya and the deforestation in the Amazon for the plantations are driven by foreign demand for soya as well as high prices for soya on the world markets – which have more than quadrupled since 1990 (HBS et al., 2013) – and not anymore by local demand (Macedo et al., 2012; Ibrahim et al., 2010; Morton et al., 2006; Greenpeace, 2009b). In Figure 27 (page 72), the correlation between the profitability and the area deforested for soya can be seen. Thus Fearnside writes in his article that “the further expansion of soybeans is entirely as an export crop” (Fearnside, 2001, p. 34).

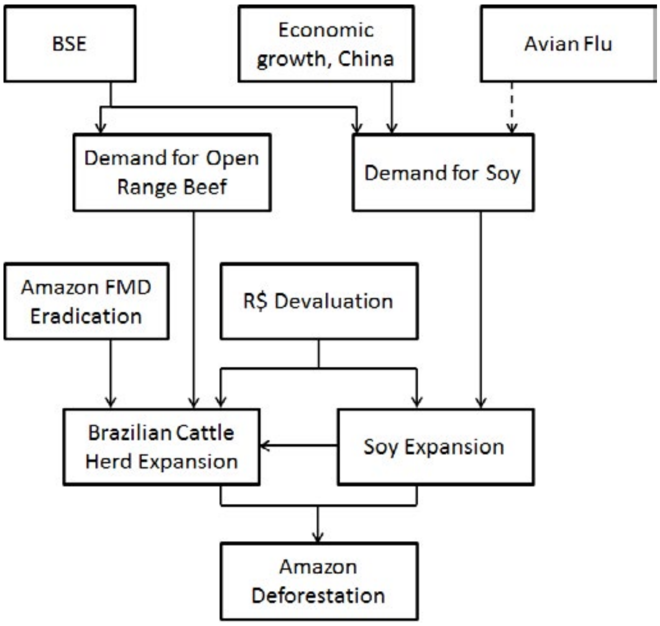


Figure 12: Economic Teleconnections: Market Forces as Underlying Drivers of Deforestation in the Brazilian Amazon (Nepstad et al., 2006a, p. 1598, reproduced with permission from John Wiley and Sons / Conservation Biology)

For the expansion of cattle pastures, economic aspects like prices and demand as well as animal health issues and meat quality standards are very important (see also Figure 11). Ibrahim et al. (2010) describe that between the 1970s and the 1990s mainly domestic demand was a driver of pasture expansion and that this has changed since then to the international market being more important as a driver.

The link between deforestation and the export of goods was investigated by Meyfroidt et al. (2010), DeFries et al. (2010) and Eden (2013). Meyfroidt et al. (2010) call it “net displacement of land” if a country imports products that caused deforestation elsewhere and “net absorption of land” if a country exports goods for which forest was cleared. They found that Brazil clearly has a net absorption of land, see Figure 13.

As can be seen, this absorption of land has increased quite dramatically since the beginning of the last decade with the increase in agricultural area and production as well as globalisation and liberalisation of markets causing an increase in exports. Even though a correlation like this cannot be found for all countries, Meyfroidt et al. (2010) state that with globalisation, net displacement of land has increased as well. Another change they realised is that since the beginning of the last decade, absorption of land is happening in fewer countries, among them Brazil.

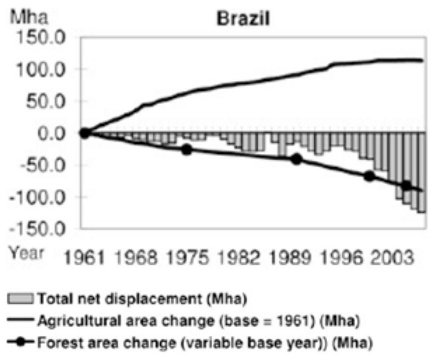


Figure 13: Negative Net Displacement or Net Absorption of Land by Brazil through its Export of Agricultural Goods (Meyfroidt et al., 2010, p. 20918, © PNAS)

Actually, the growth of net trade was strongest in Latin America (FAO, 2012) and also the agricultural exports of tropical countries like palm oil, soya beans, sugar, and meat have increased within the last years (DeFries et al., 2010). This means that deforestation in Brazil is caused by exporting so many agricultural goods like soya beans and cattle meat. Thus, other nations also have a share in and responsibility for this deforestation.

DeFries et al. (2010) summarize the change in deforestation drivers by writing that the state building roads and promoting the colonization of forested areas is less of a driver for deforestation than international trade and enterprises.

The Role of the EU

Following China and Japan, the EU is the largest net importer of agrarian products worldwide (von Witzke et al., 2011) and is a large importer of Brazilian soya. Thus it is very likely that there is net displacement of land going with its agricultural imports and that as a result the EU market is also an underlying driver of deforestation in Brazil.

Von Witzke et al. (2011) calculated in their study that an area the size of 6.43 million hectares is used in Brazil alone for the cultivation of soya and soya products that are imported into the EU, as an average of the years 2008 until 2010. This is more than 30 % of the total area planted with soya in Brazil. For cattle meat which is exported to the EU, the authors calculated an area of 0.86 million hectares of pasture in Brazil. This estimated land use of the EU in Brazil is called "virtual land use". For all agrarian products the EU imports from Brazil the "virtual land" is 9.59 million hectares, approximately the size of Portugal (von Witzke et al., 2011).

The CO_2-emissions that are associated with this land displacement or virtual land use of the EU in Brazil through its imports of agrarian products from there has not been assessed so far. What has been found out is that Germany imports around 18 million tonnes of CO_2-equivalent with its imports of soya from Brazil (Reichert & Reichardt, 2011). Effects of the whole EU and also cattle meat imports have not been quantified yet. The study at hand tries to fill this gap and to quantify the responsibility of the EU in Brazilian deforestation.

1.1.3 Indirect Land Use Change

In a lot of papers and studies, the indirect land use change (iLUC) of soya has been stated and confirmed (e.g. Arima et al., 2011; Barona et al., 2010; Searchinger et al., 2008; Nepstad et al., 2008; Andrade de Sá et al., 2012; Lapola et al., 2010; Ibrahim et al., 2010; Alves et al., 2009; HBS et al., 2013; Reichert & Reichardt, 2011; WWF UK, 2011). This phenomenon, also called the "displacement effect" or "displacement deforestation" is described as "[iLUC occurs] when agricultural activities displaced from one region drive expansion of the same land use in another region" (Andrade de Sá et al., 2012, p. 1) or more concretely: "mechanized agriculture encroaches on existing pastures, displacing them to the frontier" (Arima et al., 2011, p. 24010).

Barona et al. (2010) show in their study that areas deeper in the forest are deforested for pastures as a consequence of soya occupying older pastures, see Figure 14.

The fact that soya needs more infrastructure and better prepared soil than pastures explains why there often is a change from pastures to soya plantations and hence the expansion of the pastures deeper into the forest (Fearnside, 2001). Furthermore, with the expansion of soya plantations, land prices have risen quite fast so that ranchers sold their land to soya farmers and moved into the forest, making a lot of money with the sale of the land (Nepstad et al., 2006b; Ibrahim et al., 2010).

Another factor leading to iLUC is the soya moratorium, a voluntary agreement of soya exporters to only sell soya that has not been grown on recently deforested areas, which was signed in 2006 (GTS Soy Task Force, 2012). For example Arima et al. (2011) describe that this has caused leakage or iLUC because after 2006, more soya has been planted on pastures which led to more deforestation due

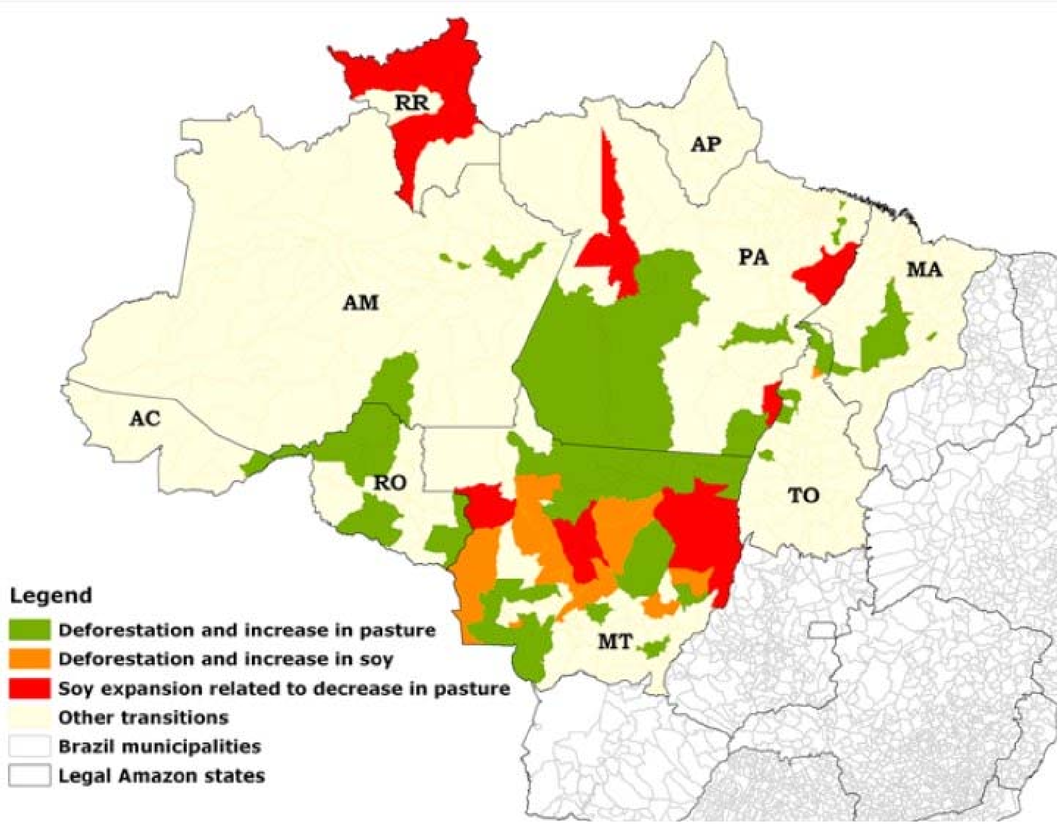


Figure 14: Areas of Deforestation for Pasture and Soya as well as Areas Where Soya Expanded on Pastures, Probably Inducing iLUC in the Legal Amazon Between 2000 and 2006 (Barona *et al*., 2010, p. 24008, © Env Research Letters)

to cattle pastures. So the celebrated "decoupling of soya and deforestation" (Macedo et al., 2012, p. 1341) is true looking at direct effects but not concerning indirect effects.

Due to the fact that iLUC does not necessarily happen in a neighbouring area and within a short period of time, it is not easy to measure (Arima et al., 2011) but there are some approaches. For example an 'iLUC factor' has been developed by Fritsche (2010) from Öko-Institut (Institute for Applied Ecology) in Germany. He says that between 3.4 and 6.8 t CO_2/ha/year need to be added to the driver of iLUC, e.g. soya. However, this approach is quite general and thus imprecise for distinct regions at the current stage (see Reichert & Reichardt, 2011; Fehrenbach et al., 2009). There are also other approaches on how to quantify iLUC but up till now none is really specific and well-developed, see Dunkelberg (2011) and Fehrenbach et al. (2009). This is the reason why iLUC has not been considered in the studies by Reichert & Reichardt (2011) and von Witzke et al. (2011).

For this study, however, an own approach to quantify the emissions that go together with iLUC has been developed and is described in detail in Chapter 3.2.

1.2 Research Approach

Below, the research approach of this study, including the need for research, the research goals, the hypotheses and the relevance of the topic, is described. Furthermore, the scope of the study and the differences to other studies are expounded.

1.2.1 Need for Research

As described in the chapter above, a correlation has been found between the amount of exported agricultural products of a country, its deforested area, and its CO_2-emissions (see Meyfroidt et al., 2010; DeFries et al., 2010; Eden, 2013). This means that CO_2-emissions are imported along with these products. The current allocation method for emissions is to add them to the exporting country where the emissions have been generated and not to the importing countries.

In order to address this demand-side pressure on deforestation by importing countries and to trigger policy responses on the mitigation of deforestation as well as on more just allocation methods, the imported deforestation and related direct and indirect emissions need to be quantified.

Up until now no quantification of that has been done for the EU for both cattle meat and soya. There is a study by von Witzke et al. (2011) in which they calculated the area of land used by Germany and the EU for nearly its whole agricultural imports from numerous countries but it is not stated how much deforestation is associated with this study. Furthermore, there is a study by Reichert & Reichardt (2011) in which the total emissions for soya that is imported to Germany have been calculated.

There is, however, a need to know about the deforestation and emissions of the EU because most of the strategies dealing with avoided deforestation are located on the international or EU level. For example, measures dealing with the agricultural system in the EU have to be integrated into the Common Agricultural Policy (CAP) of the EU. An assessment should look at the most relevant agrarian imports to draw a complete picture of the impacts and not just at a single commodity.

Another important component of this study is that neither of the two existing studies mentioned above nor in any other comparable study dealing with the topic, indirect land use change is quantified. Nevertheless, figures used in the political debate on imported deforestation and emissions need to be as accurate as possible – that is why they are specifically addressed and quantified in this study using a new method.

1.2.2 Research Goals and Aim of the Study

The aim of the study is to find out as precisely as possible how much deforestation and thus CO_2-emissions in Brazil are caused through the EU's imports of soya and cattle meat. Then it will be possible to tell whether or not the EU is a major driver of deforestation in Brazil and how large its responsibility is in causing GHG-emissions for these two commodities.

1.2.3 Hypotheses

Two hypotheses or research questions have been defined and will be answered and discussed in this study:

1. The EU causes deforestation and CO_2-emissions in Brazil to a non-negligible amount by its import of cattle meat and soya.

2. The deforestation emissions of soya are too low in the calculations for hypothesis one because soya is systematically planted on pasture land which has only been deforested some few years before.

To evaluate hypothesis one, the CO_2-emissions will be calculated using the "common way" of calculation, similar to Reichert & Reichardt (2011). If these results are deemed to be non-negligible, hypothesis two will be analysed for indirect emissions using a method developed here.

1.2.4 Relevance of the Topic

To avoid dangerous climate change, the emissions of GHGs need to be mitigated. This includes the decrease or halt of deforestation which causes a significant amount of GHG-emissions.

Deforestation in the Amazon is especially damaging because the forest stores massive amounts of carbon that may be released into the atmosphere following deforestation and because the Amazon fulfils a lot of crucial socio-economic functions for the region. This includes the Amazon being an important source of fresh water, having an extremely high biodiversity, being a habitat for a lot of indigenous people and much more (see e.g. Nepstad et al., 2008; Greenpeace, 2011; HBS et al., 2013).

Nepstad et al. (2008) draw a very dramatic picture of how the fate of the Amazon in the next 20 years could look like: "If sea surface temperature anomalies (such as El Ninõ episodes) and associated Amazon droughts of the last decade continue into the future, approximately 55 % of the forests of the Amazon will be cleared, logged, damaged by drought, or burned over the next 20 years" (Nepstad et al., 2008, p. 1737). Lenton et al. (2008) describe in their study that this rainforest in Latin America is even a tipping element in the global climate system and that it could turn into a savannah-like state if a critical area was deforested and if global temperature rose by three to four degrees Celsius compared to pre-industrial levels. After this tipping point has been exceeded, there will most likely not be a way back for the Amazon to become a rainforest again (Lenton et al., 2008). This means that deforestation and global warming need to be mitigated in order to prevent this system from a dieback within the next decades.

For effective mitigation of deforestation worldwide, the drivers of this deforestation need to be identified, understood, and quantified as well as possible – the domestic ones and the international ones. This demand has also been made in the Cancun Agreements, the outcomes document of the UNFCCC COP 16 in 2010 (Boucher, 2011). The economic drivers of deforestation in Brazil which have been described in the chapter above need to be better investigated because, until recently, the underlying drivers and their interconnections have not been fully understood, and far less been quantified. Only if the respective countries are known and if their share in deforestation is quantified, can they be made accountable and the pressure on the forests through international demand addressed and minimised.

This is due to the fact that if there is a reliable and comprehensible account, policy instruments, and voluntary agreements like REDDplus (Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of carbon stocks in developing countries), FLEGT (Forest Law Enforcement, Governance and

Trade) and the RTRS (Round Table on Responsible Soy) can be designed in a more effective way. Additionally, other more specific instruments can be developed if the drivers of deforestation and their shares in deforestation are known.

The European Commission realized the relevance of this topic as well and tendered a study called "The impacts of EU consumption of food and non-food imports on deforestation" in 2009. The study shall be published this year (European Commission, 2009). As an important importer of agricultural goods, the EU should have an influence on the production of the goods and has a responsibility of what happens during the production of goods consumed in the EU (see e.g. Reichert & Reichardt, 2011). So for the EU it seems to be relevant if it is a major driver of deforestation in Brazil and how large its impact is on CO_2-emissions through deforestation.

In the end, knowing about the role of the EU and other countries in deforestation in Brazil is a matter of justice because countries often blame Brazil of its high deforestation rate and CO_2-emissions and are proud of themselves to have reached the Kyoto targets or to have just little deforestation or even afforestation. By relating deforestation emissions in Brazil to consumption of agricultural products in other countries, the current allocation method for GHGs can be questioned. Is it fair that these emissions are assigned to Brazil? Do we need a reform of this allocation method in the national GHG inventories? Would the EU reach its Kyoto targets if displaced emissions were considered? Could a reform of the allocation method lead to less displacement of land hence emissions as well as to less GHG-emissions in general?

All of these and more questions can be asked on the basis of the outcomes of this study more concretely. It can therefore be seen as an important input for the current debate on how to reduce emissions from deforestation.

1.2.5 Scope of the Study

This study only focusses on deforestation and CO_2-emissions from deforestation due to cattle pastures and soya plantations because they have been identified as the main drivers of deforestation in Brazil. Further import commodities of the EU from Brazil like coffee, cocoa, grain maize, poultry meat, tea and tobacco (von Witzke et al., 2011) are thus not part of this study. Also timber has not been looked at. Therefore, the study at hand rather underestimates the impacts of the EU's and other country's imports on deforestation in Brazil a bit.

Moreover, deforestation is just considered in the Amazon and the Cerrado where 90 % of the Brazilian CO_2-emissions from land use change and forestry are caused (MCT Brazil, 2010). This is because for these biomes data are available. Forest degradation and related emissions are also not looked at here.

Other GHGs related to deforestation are not examined. The focus on CO_2-emissions was made because more data for CO_2-emissions are available due to the fact that it is the most looked at GHG at the moment. So, if there is the term "deforestation emissions" mentioned in this study, this relates only to CO_2, if not mentioned differently at the respective paragraph.

Furthermore, CO_2-emissions going with the transportation, processing, packaging and other activities related to cattle meat and soya export are not looked at because Reichert & Reichardt (2011) found out that the deforestation emissions make up the majority of the total life cycle emissions of soya. Another reason is that just the share of the EU's imports on deforestation and emissions was the focus of this study in order to answer the question if the EU is a major driver of deforestation in Brazil. Therefore, also emissions from other land use changes for pastures and plantations were not looked at.

All calculations have been done for CO_2-emissions from deforestation at first and are described in detail in the chapter "Results". The deforestation caused in hectares by the EU and other countries is just mentioned in a small chapter afterwards. If just deforestation was looked at by itself, no comparison with the domestic emissions of the EU could have been made and it becomes more concrete if a consequence of deforestation is looked at and quantified exemplarily. The quantification of CO_2-emissions allows also a direct link to climate change, the Kyoto targets, REDDplus, and other instruments to mitigate climate change.

The study and its results are just valid for the years between 2002 and 2008 because only for these years all needed data for the calculations has been found.

1.2.6 Differences to the Study by Reichert & Reichardt (2011)

Although the study by Reichert & Reichardt (2011) may seem similar to this study, there are three important differences.

First, this study examines Brazil and the deforestation through export of products there. Including other countries like Argentina and Paraguay with country-specific values for most of the figures used would have been too time- and page-consuming for the expected scope of a master's thesis.

Second, the EU and not just Germany was taken as the major importer of some of Brazil's commodities. This decision was due to the fact that a lot of laws and programmes concerning trade and agriculture cannot be made by single member states but are e.g. defined by the CAP.

Third, this study covers not just soya as the study by Reichert & Reichardt (2011) did. This study covers both cattle meat and soya which are the two major drivers of deforestation in Brazil and also important export commodities. Using these two commodities, the majority of the total impact of the EU in deforestation in Brazil can be assessed.

1.3 The Study Region Brazil

In the following subchapters, the study region Brazil will be presented. This includes the rationales for choosing this country for the study at hand, a description of the region including important facts and figures, and a chapter on the legislation and important national programmes to protect the forest.

1.3.1 Rationales for Choosing Brazil

The reasons why this study looks at the deforestation in Brazil are firstly, that the absolute loss of forest in Brazil, with more than 2,6 million hectares annually between 2000 and 2010, is the largest in the world (see also chapter 1.1). This is why nearly two thirds of the global CO_2-emissions from land use change in 2005 were from Brazil and Indonesia (WBGU, 2011). In Brazil, land use change and forestry accounted for 1,258,626,000 tonnes of CO_2-emissions which are 77 % of Brazil's total CO_2-emissions, see Figure 15, or 61 % of its GHG-emissions (MCT Brazil, 2010). As has been shown in Figure 8, the global average is that emissions from the forestry sector account for 17.4 % of all GHG-emissions (IPCC, 2007).

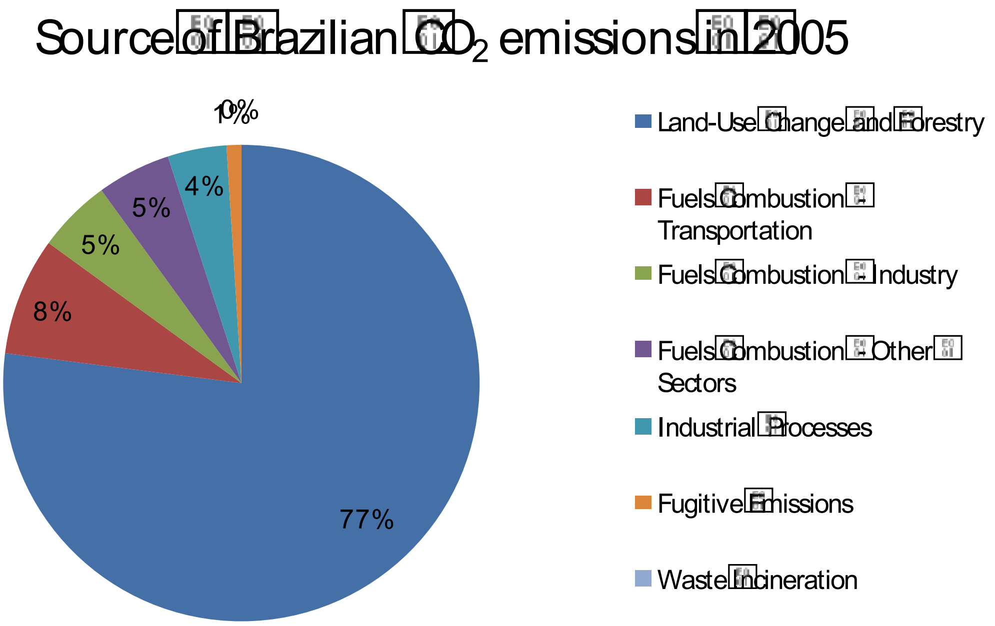


Figure 15: Sectoral Distribution of the CO_2-emissions of Brazil in 2005 (own figure based on data from MCT Brazil, 2010, p. 138)

Secondly, Brazil is one of the most important production as well as export countries for many agricultural products. It has increased its production significantly within the last couple of years and due to the fact that the domestic demand did not grow at the same pace, the increase in net trade is one of the highest in the world (FAO, 2012). Agricultural exports made up 36 % of the total exports of Brazil in 2012 and are growing. Among them, soya products are the most important; the second most important are meat products. In 2010, 97 % of all exported soya beans came from just three countries: the US, Brazil and Argentina (own calculation, data from FAOSTAT, 2012). The US has always been leading but in the harvesting year 2012 / 2013, Brazil could overtake it with its soya exports for the first time (Agra-Europe, 2013).

Concerning beef meat, Brazil is the largest exporter of this commodity worldwide since 2003, currently followed by Australia (FAOSTAT, 2012; Greenpeace, 2009b). Its role as the major exporter of beef meat rose dramatically since 2000 when it exported only 20 % of what it exported in 2010 (data for 2010, own calculation, data from FAOSTAT, 2012). This data shows that Brazil is a major player for the commodities which are looked at in this study.

Furthermore, Brazil is the most important trading partner for these commodities of the EU. After Argentina, the EU imported most of its cake of soya beans and cattle meat from Brazil and it imported most of its soya beans from Brazil (all data for 2010, own calculations, data from FAOSTAT, 2012).

The correlation of deforestation in Brazil with its agricultural exports of soya beans and beef meat has been proven in various studies (Meyfroidt et al., 2010; DeFries et al., 2010; Eden, 2013; Nepstad et al., 2006; Morton et al., 2006). This means that all countries that import agricultural products from Brazil are likely to contribute to its deforestation.

Another important reason for choosing Brazil is that there has been a lot of investigation into the impacts of cattle ranching, soya production, and deforestation already and there is quite reliable and more data available than for e.g. Argentina or Paraguay through INPE (it stands for Instituto Nacional de Pesquisas Espaciais, in English: Brazilian National Institute For Space Research). Compared to other countries in Latin America, a large portion of the data as well as many studies are available in English.

1.3.2 Description of the Study Area

The map below (Figure 16) shows the major land uses in Brazil. Following the Russian Federation, Brazil is the second largest forest-rich country in the world with 520 million hectares of forest in 2010 (FAO, 2010). This area is equal to 62 % of the land area of Brazil. Additionally, in Brazil there is 5 % of other wooded land (FAO, 2010).

As can be seen in the map, cropland is a very important type of land use. Brazil even has the largest area of soya plantations worldwide (von Witzke et al., 2011). In 2011, soya covered 23,968,700 hectares – compared to 1997 the area more than doubled (own calculation, data from FAOSTAT, 2012). In general, the Brazilian agricultural sector (including crop as well as livestock production) is important for the country's economy: in 2007 it made up 25.1 % of its GDP (Ibrahim et al., 2010).

Below, the two most important biomes where deforestation takes place are described in more detail.

Description of the Amazon

The Amazon is the largest connected rainforest in the world with 43 % of dense forest (HBS et al., 2013; FAO, 2009) and covers an area of about 6.5 million km² in nine countries of South America from which 60 % is located in Brazil (Greenpeace, 2009b). The vegetation distribution of the Amazon can be seen in Figure 17. The Amazon is home to more than 200,000 indigenous people (Greenpeace, 2006) and has an incredible biodiversity – one of the highest in the world with "nearly 10 % of the world's mammals and […] 15 % of the world's known land-based plant species" (Greenpeace, 2006, p. 5) as well as nearly 400 tree species per hectare (MCT Brazil, 2010). Furthermore, there is the world's largest system of rivers in the Amazon (Greenpeace, 2009b), it is therefore very important for the global climate system and a tipping element threatened by global warming and deforestation (see Chapter 1.2.4).

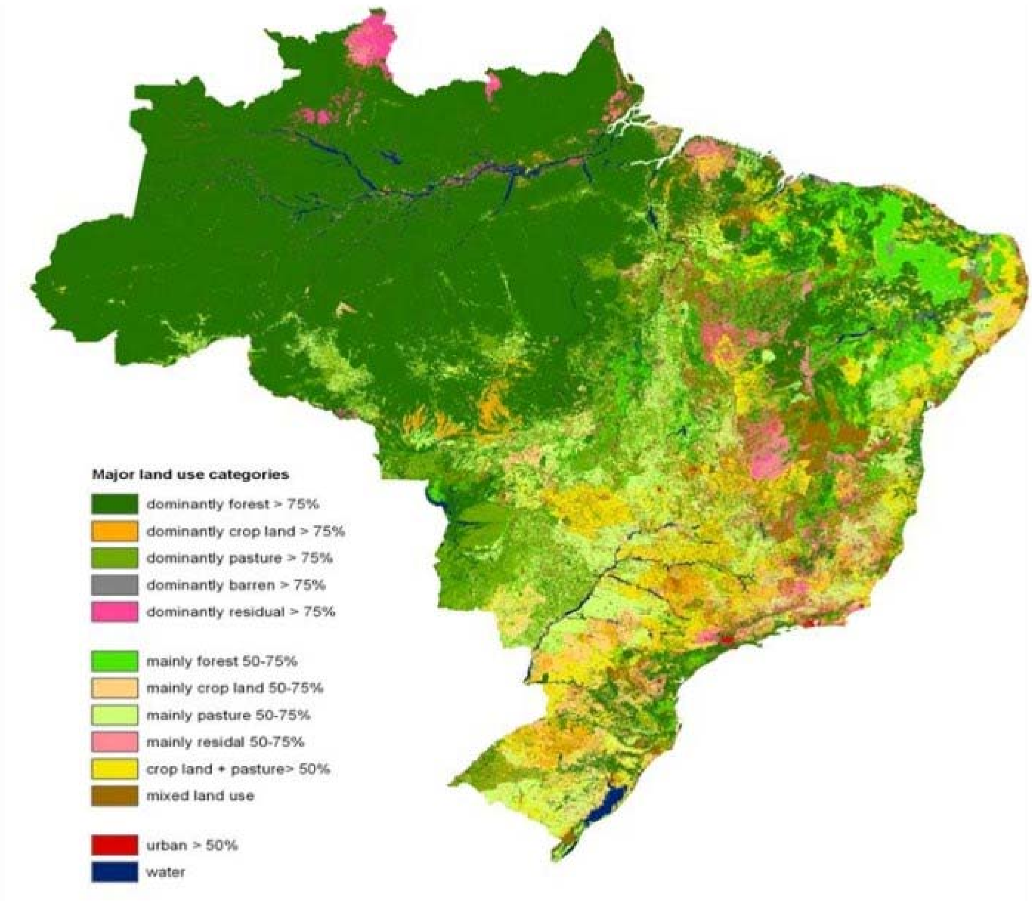


Figure 16: Major Land Use Categories in Brazil in 2006 (Ermolieva et al., 2012, p. 129, reproduced with permission from the International Institute for Applied Systems Analysis (IIASA))

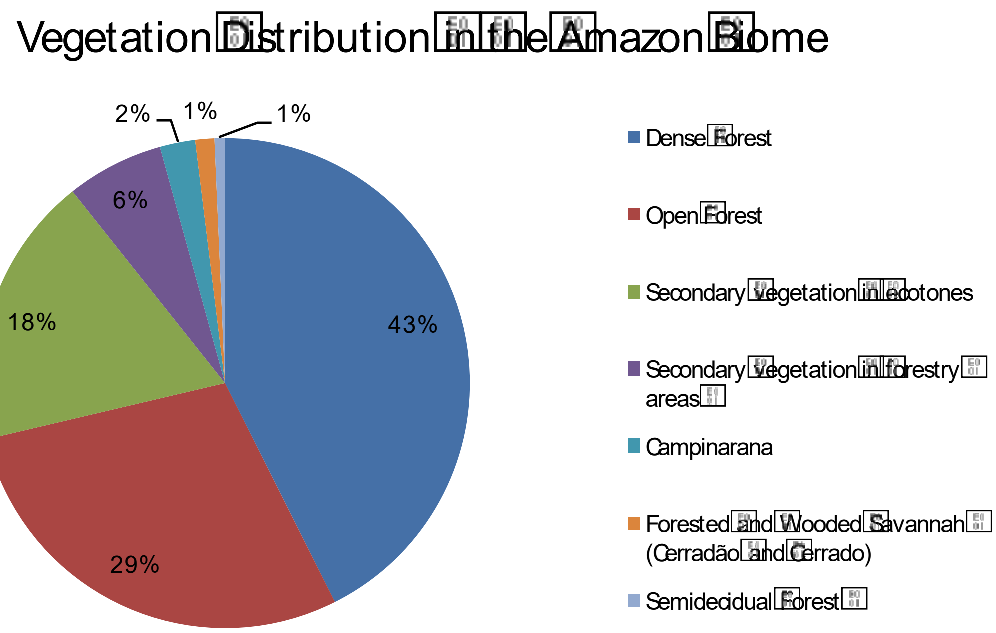


Figure 17: Vegetation Distribution in the Amazon Biome (own figure, data from FAO, 2009)

Within Brazil, the states where the Amazon is located have been clustered to the Legal Amazon in 1966, a geopolitical construct. It contains nine Brazilian states, two of them just partly, or 60 % of Brazil (Andrade de Sá **et al.**, 2012). Within Brazil, 24 % of the Amazon is private area, 29 % is legally protected area including indigenous land and 47 % is public and / or unoccupied land (MCT Brazil, 2010, p. 350).

The Amazon has become famous not only for its biodiversity but also for its high rate of deforestation. More than 700,000 km² of the native vegetation has gone already (Greenpeace, 2006). Margulis (2004) states in his report for the World Bank, that "in contrast to the 1970s and 1980s when occupation of Brazilian Amazonia was largely induced by government policies and subsidies, recent deforestation in significant parts of the region is basically caused by medium- and large-scale cattle ranching" (p. xi). Also Greenpeace (2006) and other studies support this statement and add that pasture areas and cattle numbers have increased in most years since the 1970s. This is especially due to the fact that land in the Amazon is quite cheap and cattle ranching is profitable there (Greenpeace, 2009b). The role of roads in opening up the forest is emphasised. A hotspot for deforestation is the state of Mato Grosso, which belongs partly to the Legal Amazon, which has also the highest number of cattle in Brazil (Greenpeace, 2009b).

Land use change in the Amazon made up 52 % of Brazil's CO_2-emissions in 2005 (MCT Brazil, 2010).

Description of the Cerrado

The Cerrado, a savannah-like ecosystem, covers nearly 24 % of the total land area of Brazil (MCT Brazil, 2010), so more than 2 million km² (Hance, 2010). The location within Brazil can be seen in Figure 18. The word Cerrado means "closed" or "inaccessible" in Portuguese (Wagner-Carrozza, 2005).

The vegetation distribution can be seen in Figure 19.

Figure 18: Location and Extent of the Cerrado (WWF, 2014, p. 11)

The Cerrado has been described as a forest standing on its head because 70 % of the living biomass is estimated to be belowground (Klink & Moreira, 2002, WWF UK, 2011). It has a very high biodiversity with about 160,000 species and an especially diverse flora. Furthermore, 28 % of all amphibian species in the Cerrado are endemic and can live there and nowhere else (Oliveira & Marquis, 2002). The Cerrado is also important for the water storage and supply of the country (Portal Brazil, 2010; WWF UK, 2011).

Since the 1930s, the Cerrado was more and more accessed and integrated into the economic system through government action like cheap loans, subsidies, fertilizer and lime application, and research on adapted species. In the 1960s the agricultural expansion into the Cerrado began (Klink & Moreira, 2002; WWF UK, 2011; Hance, 2010). Even though the soils are mostly poor, 62 % or 127 million hectares are estimated to be suitable for agriculture. 66 million hectares are used as pastures and 18 million hectares are used as cropland, mostly for cash crops like soya beans; other crops are corn, rice, cotton and coffee (Lal, 2008; Klink & Moreira, 2002). Lately, sugar cane for biofuel production got more important, and another important use of native Cerrado trees is charcoal production used in the steel industry (WWF UK, 2011; Soybean and Corn Advisor, 2010). The agricultural system is "capital-intensive, large-scale [and] mechanized" (Klink & Moreira, 2002, p. 69).

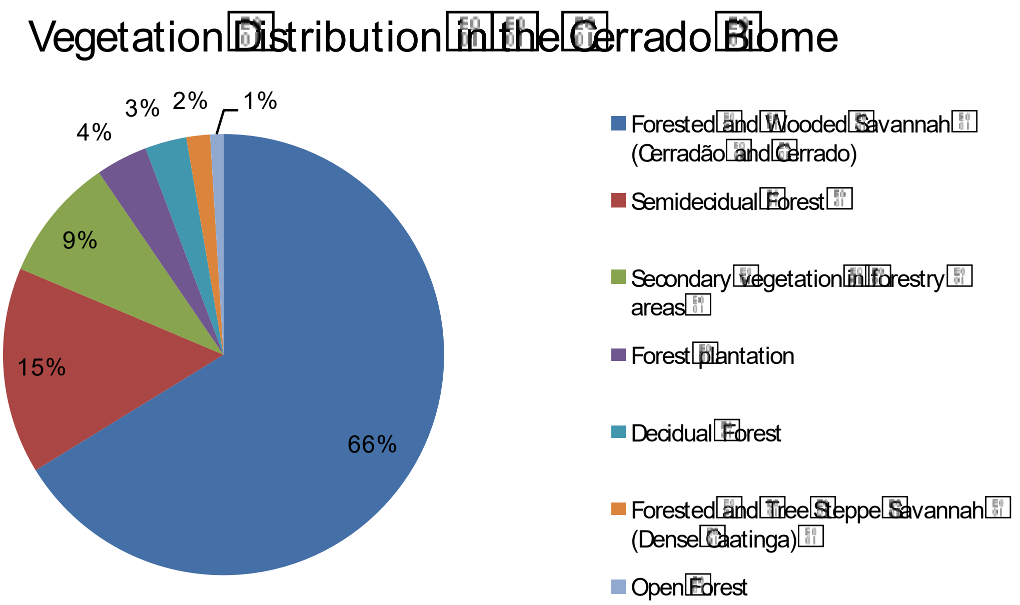


Figure 19: Vegetation Distribution in the Cerrado Biome (own figure, data from FAO, 2009)

In 2005, emissions from land use change in the Cerrado made up 17 % of Brazil's CO_2-emissions (MCT Brazil, 2010). To make the wording within this study easier and more homogenous, land use change in the Cerrado is also called deforestation here because as can be seen above, around 90 % of the Cerrado is forested.

1.3.3 Description of Legislation and Programs in Brazil to Protect the Forest

There are several levels where forest protection happens in Brazil: the national level, the subnational or state level and the private sector level. As a short summary, there is a national forest law since 1965 in Brazil as well as subnational laws. Furthermore, there is a national forest programme since 2000 and there are subnational forest policies (MCT Brazil, 2010; FAO, 2010).

Since 2008, there is also the more comprehensive National Policy on Climate Change (NPCC) which is seen as Brazil's flagship legislation on climate change (GLOBE International, 2013). It addresses deforestation and afforestation in its objectives four and five. In Figure 20 it can be seen that the Amazon deforestation shall be reduced to approximately 5,000km² by 2017 (Government of Brazil, 2008). By 2020, it shall be reduced by 80 % (Boucher et al., 2011).

After the peak of Amazon deforestation in 1995, a governmental action to tackle it called "Amazon Package" was implemented in 1996. The two measures it consisted of were a moratorium on mahogany and baboon licenses and a restriction of clear cuts on more than 20 % of a property (MCT Brazil, 2010). In 2004, another plan to combat Amazon deforestation, called "Action Plan for Prevention and Control of Deforestation in the Amazon" (PPCDAM), entered into force. It includes regularising the land use, monitoring the environment with the systems PRODES (that is the Amazon Forest Satellite Monitoring Project) and the more precise one DETER (this stands for Real Time Deforestation Detection) and other measures (Portal Brazil, 2012; MCT Brazil, 2010).

Deforestation in the Cerrado has been mainly unconsidered for a long time. Only in 2010, a decree to establish the PPCerrado, the "Action Plan for Prevention and Control of Deforestation and Wildfires in Cerrado" was signed by Brazilian President Lula da Silva. This plan aims at reducing the deforestation in the Cerrado by 40 % until 2020. As announced in a press release of the Brazilian government on "Portal Brazil", the action plan "outlines 151 actions to significantly reduce the loss of vegetation cover and promote the protection and sustainable use of natural resources in the biome" and will therefore also contribute to the aims of the National Policy on Climate Change. Most important in the plan are actions in 20 municipalities that have been identified as most deforested. Alternatives for a more sustainable development will be proposed for them (Portal Brazil, 2010).

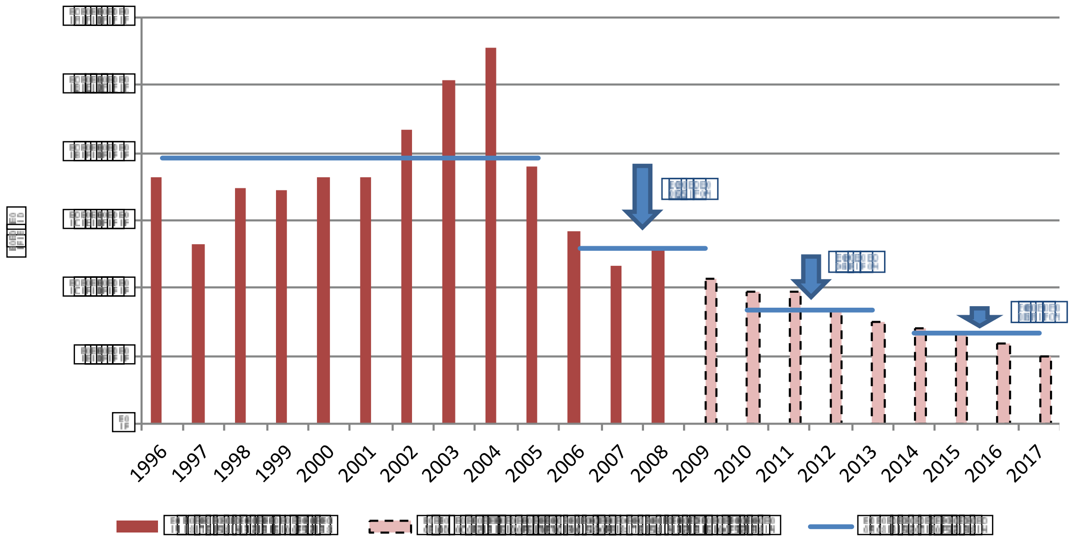


Figure 20: Planned Reduction of Amazon Deforestation until 2017 in the National Plan on Climate Change of Brazil (own figure, based on Government of Brazil, 2008, p. 14)

In December 2012 the new Forest Code (FC) entered into force, aiming at land owners to obey the existing law of keeping 80 % of a property in the Amazon and 35 % of a property in the Cerrado as legal reserves. It also includes an element similar to emission trading schemes because now it is possible to trade forest protection area certificates among land owners. This system is called "Bolsa Verde do Rio de Janeiro" or short BVRio. This means that if somebody buys enough certificates from somebody else who protects more of his or her forest than needed, it is possible that the buyer is no longer obliged to protect an area within his or her own forest land. For emission trading, this model seems to be a good way although, e.g. in the EU the ETS (Emissions Trading System) is not really working at the moment. However, in the Brazilian Amazon this new law could even lead to more deforestation in the end as Jutta Kill, a forest consultant, writes in her article (2013). It seems like in remote areas of the Amazon where deforestation would not really have been a problem people buy land just to sell certificates so that others can deforest their land legally. She concludes that this new law has dramatic consequences for the Amazon because it releases the forest owners from their binding responsibility to protect 80 % of their own forest land hence to contribute to combating deforestation.

Of course, there are also national and state protected areas in Brazil; in 2000 a National System of Protected Areas (SNUC) was introduced. Altogether, they cover an area of more than 15 % of Brazil, though just 5.2 % of this area is fully protected; the rest is "sustainable use zone". Of the Amazon, 6.67 % is fully protected and only 2.24 % of the Cerrado is fully protected. Additionally, there are indigenous reserves all over the coury (MCT Brazil, 2010).

Then, there is the Environmental Crimes Law which defines penalties for environmental violations and to protect the Amazon, 2,000 military soldiers are stationed there (MCT Brazil, 2010; Ibrahim et al., 2010). In the forest resources assessment of the FAO (2010) it is stated that the public expenditure on forest protection in Brazil was really low compared to other countries with less than 0.1 US dollar per hectare. Ibrahim et al. (2010) note that there are problems with law enforcement in the Amazon as resources and infrastructure is missing.

However, there are several funds like the Brazilian Biodiversity Fund that provides financial support to protected areas, the National Fund for Climate Change and the Amazon Fund, established in 2008, which is financed by donations, also from foreign governments, and which funds projects in the Amazon (MCT Brazil, 2010). Furthermore, investment in forest-destructive activities was a big problem. Consequently, the “Green Protocol” of 1995 is a declaration of banks not to finance unsustainable projects anymore (MCT Brazil, 2010). In the Amazon, there is moreover a Forest Stewardship Programme since 2007 from which indigenous communities get payments for ecosystem services if they do not deforest (Ibrahim et al., 2010).

There are also some important initiatives of the business sector: the soya moratorium which entered into force in 2006 and the beef and leather moratorium that was created in 2009. The soya moratorium is a voluntary agreement signed by industry and members of ABIOVE, the Brazilian Vegetable Oil Industries Association as well as members of ANEC, the National Grain Exporters Association. These industries committed to only sell soya that has not been grown on recently deforested areas (GTS Soy Task Force, 2012). There is as well the Round Table on Responsible Soy (RTRS) where the soya industry and representatives of civil society develop criteria of a certification system for sustainable soya (WWF UK, 2011). The beef and leather moratorium is a voluntary instrument by the cattle industry in Brazil. Farmers need to register their ranches and then their properties get checked for deforestation regularly through a deforestation verification system (Boucher, 2011; Greenpeace, 2011). With these systems, the growing demand for deforestation-free meat, leather and soya from abroad but also from within Brazil can get satisfied (Nepstad et al., 2006b).

These were just the most relevant elements of Brazilian legislation concerning deforestation. There are more programmes, funds and laws in Brazil which are not described above because this would have needed a lot more pages.

1.4 Rationale for Choosing the EU

The reason why the EU was especially looked at in this study is that it is the third largest importer of agricultural products in the world (von Witzke et al., 2011). It also imports a large proportion of Brazilian agricultural products: in 2010, it imported 69 % of the Brazilian exports of cake of soybeans, 23 % of the Brazilian exports of soybeans following the largest importer China, and 5 % of Brazilian cattle meat which was ranked 5 among other importing countries (own calculations, data from FAOSTAT, 2012).

Another aspect is that there is a similar study looking at the soya imports and related impacts of Germany in Latin America (see Reichert & Reichardt, 2011). However, major decisions related to trade policies are made on the EU-level, so a study considering the whole EU will be more useful for policy making that is addressing deforestation. Related to this aspect is the fact that for Germanwatch and its political lobby activities, the EU is a major target group.

The EU is also a very important global player in climate change mitigation efforts as well as in the field of REDDplus and other tropical forest-related policies (e.g. FLEGT) that seek to address demand-side pressure on forests. Thus, if the drivers of deforestation are better understood and quantified and if the role of the EU in it becomes clarified, policies of the EU and international ones, for which the EU is a leading developer, have a higher chance of being designed more effectively to better minimise the pressure on Brazil's and other forests.

1.5 Rationale for Focussing on Soya and Cattle Meat Exports

An important aspect for looking at cattle meat and soya is that these two commodities are the major drivers of deforestation in Brazil and are also predicted to expand further. The influence of soya bean and cattle meat exports on deforestation has been studied by Eden (2013) – among other countries also for Brazil. He found out that soybean as well as cattle meat exports from Brazil correlate with the country's deforestation and thus that deforestation is likely to be a consequence of the export of these two commodities. So the question if the EU is a major driver of deforestation in Brazil can be answered by just looking primarily at the EU's imports of these two commodities.

The beneficial aspect for this study is that because cattle and soya are such important drivers of deforestation, the topic is more or less well-researched, thus the data availability is quite good.

Besides deforestation, there are also other negative aspects coming with the expansion of cattle pastures and soya plantations, which should at least be mentioned to get a full picture of the impacts of these two commodities. By stopping deforestation for cattle meat and soya, also these negative effects could be reduced or halted.

The negative effects coming with cattle pastures are among others slave labour, which has been detected to occur on quite a few cattle ranches, the invasion of indigenous land by the ranchers and land degradation when pastures are not properly managed. Furthermore, grass pastures have one of the lowest biodiversity (Greenpeace, 2006 and 2011; Ibrahim et al., 2010).

Concerning soya, there is for example a displacement of indigenous people and small farmers happening due to its expansion and the related infrastructure, there are health problems occurring related to herbicide use on soya plantations and weeds are getting more and more resistant against them so that more and more chemicals have to be sprayed, also leading to more health problems. Furthermore, a large percentage of the soya planted in South America is genetically modified, causing additional problems (Agrar Koordination, 2012; Reichert & Reichardt, 2011; WWF UK, 2011).

However, this study at hand only looks at the effects of soya plantations and cattle pastures on deforestation and resulting CO_2-emissions.

In the two subchapters below, some facts and trade statistics of cattle meat and soya are described in more detail.

1.5.1 Cattle Meat – Extensive Pastures, Distribution, and Trade Statistics

In the EU cattle is fed with compound feed including soya, in South America cattle is mainly grazing on pastures; this is called extensive land use (Macedo et al., 2012). Due to that, 70 % of the Brazilian area that is usable for agriculture is used as cattle pasture (HBS et al., 2013). These pastures are threatening the forests. So the cattle meat imported from Brazil does not really have an indirect effect on deforestation (due to animal feed) but has a direct one (von Witzke et al., 2011).

In 2007, 35 % of Brazil's cattle herd was located in the Legal Amazon (own calculation, data from IBGE, 2007). Compared to whole Brazil, where the growth in cattle number between 1996 and 2005 was 14 %, the number of cattle in the Legal Amazon grew by 110 %. In the North region it increased by 900 % between 1975 and 2005 with the largest growth in the last decade (Ibrahim et al., 2010, data from IBGE, 2007). In the North of Brazil, the farms are mostly large ones with less than five per cent of all registered farms occupying more than 75 % of the total farm area (Ibrahim et al., 2010). The benefits from this large-scale cattle ranching only go to a few big players and do not contribute to the wealth of the community (Margulis, 2004; MCT Brazil, 2010).

Beef meat imports only make 0.27 % of the total agricultural imports of the EU, thus do not play a major role, but Brazil, where 35 % of this beef meat comes from, is quite an important trade partner for the EU after Argentina (own calculations, data from European Commission, 2012, and FAOSTAT, 2012; see also Table 1). In 2010, the meat exported from Brazil to the EU corresponded to 131,871 animals (own calculations following von Witzke et al., 2011, data from FAOSTAT, 2012).

Table 1: Agricultural Imports of the EU Total and from Brazil in 2011 [1,000 tonnes, CW = Carcass Weight] (data from European Commission, 2012)

	Imports From Non-EU-27	Share of Total Imports	Imports From Brazil	Share Brazil of Commodity Imports
Animal feed	56,909.00	54.46 %	14,525.00	26 %
Cereals total (incl. feed cereals)	14,037.00	13.43 %	1,052.00	7 %
Wine (in 1000 HL)	13,575.00	12.99 %	3.30	0 %
Fruits	6,350.00	6.08 %	436.00	7 %
Sugar	4,411.00	4.22 %	1,627.00	37 %
Veg fats & oils	3,572.00	3.42 %	171.00	5 %
Vegetables	1,689.00	1.62 %	1.40	0 %
Rice	1,593.00	1.52 %	97.00	6 %
Raw tobacco	630.00	0.60 %	180.00	29 %
Poultry meat (Incl Live) in CW	509.00	0.49 %	293.00	58 %
Potatoes	393.00	0.38 %	–	0 %
Beef meat (Incl Live) in CW	287.00	0.27 %	101.00	35 %
Sheep & goat meat (Incl Live) in CW	216.00	0.21 %	no data	
Milk & milk prod	81.00	0.08 %	–	0 %
Olive oil	78.00	0.07 %	–	0 %
Cheese & curd	74.00	0.07 %	no data	
Butter & butter fats	48.00	0.05 %	no data	
Caseinates	24.00	0.02 %	no data	

	Imports From Non-EU-27	Share of Total Imports	Imports From Brazil	Share Brazil of Commodity Imports
Pork meat (Incl Live) in CW	16.00	0.02 %	–	0 %
Lactose & syrup	10.00	0.01 %	–	0 %
SUM	**104,502.00**	**100.00 %**		

1.5.2 Soya – Properties, Importance and Trade Statistics

Soya (Glycine max L.), being very protein-rich, is one of the world's most important crops, grown globally over an area the size of Egypt. Soya has seen a large increase in its planted area recently, especially in Brazil, and the largest rates of expansion compared to all other crops since 1970 (von Witzke et al., 2011; WWF UK, 2011). Going together with that as well as gains in productivity, the production of soya beans has also increased nearly tenfold since 1961 (WWF UK, 2011).

Soya is a cash crop and around two-thirds of all soya products are traded (WWF UK, 2011). As 79 % of it is used as animal feed while only 19 % is used as human food and two per cent is used for other purposes, the expansion of soya can be explained by the increase in global meat consumption which has doubled compared to 1950, and even quadrupled compared to 1850 (von Witzke et al., 2011; WWF UK, 2011). This trend is predicted to continue in the future, thus also the demand for soya will increase in the future (HBS et al., 2013; WWF UK, 2011).

The animal feed is nearly solely soya flour (also called soya cake) which is – besides soya oil – a product of the compression of the soya beans in the oil mills. This is also the form of soya the EU mainly imports (von Witzke et al., 2011).

Especially for pig – which is the most produced and consumed meat in Germany – and poultry feed, soya is an important ingredient making up 20 – 30 % of the feed. However, 232g of soya flour is used to produce one kilogram of cattle meat (Reichert & Reichardt, 2011; von Witzke et al., 2011).

The countries where 93 % of all exported soya in 2010 came from are the US, Brazil, Argentina, and Paraguay. These four countries are also the ones expected to play a major role in the future. The main importers are the EU with a negative trend and China with a positive trend (Agra-Europe, 2013; WWF UK, 2011). The strong differences in import demand and export potential can be seen in Figure 21.

For the EU, in 2010 the most cake of soya beans came from Argentina followed by that from Brazil. The largest supply of soya beans came from Brazil followed in second by the United States and Paraguay (own calculations, data from FAOSTAT, 2012).

41 % of Brazil's exported soya (cake and beans) was imported by the EU in 2010 (own calculation, data from FAOSTAT, 2012). The importance of animal feed in the agricultural imports of the EU can also be seen in Figure 22 and Table 1 (above): the share of animal feed is 54 %.

As a single commodity, soya cake has the largest share of all imports with 29 % of the EU's agricultural imports. 43 % of this imported soya cake comes from Brazil (own calculations, data from European Commission, 2012; see Table 2). Von Witzke et al. (2011) calculated that with its imports of soya, the EU uses 6.4 million hectares or 30 % of the total area where soya is harvested in Brazil.

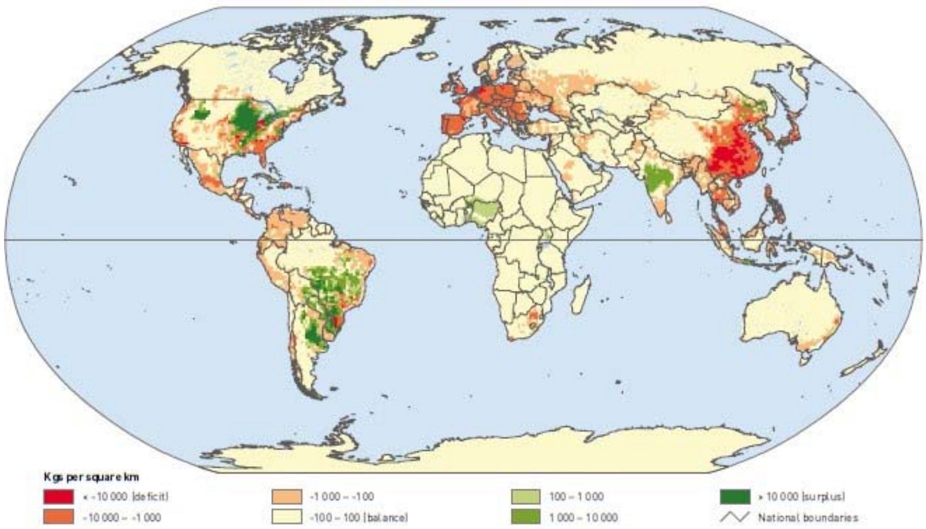


Figure 21: The Estimated Surplus or Deficit of Soya Meal for Pig and Poultry Showing the Import Demand and Export Potential for this Commodity (© FAO, Steinfeld, 2006, p. 346)

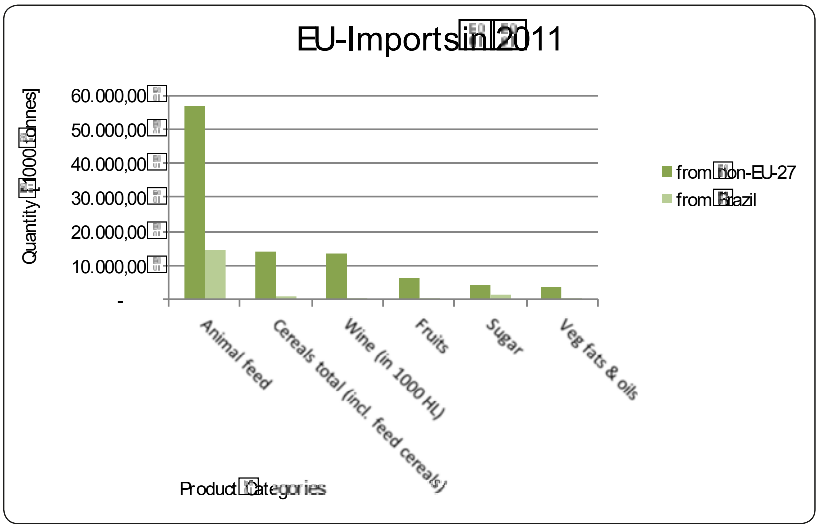


Figure 22: Overview of Some of the Agricultural Imports of the EU by Product Category and Imports from Brazil of these Products (own figure, data from European Commission, 2012)

Table 2: Animal Feed Imports of the EU Total and from Brazil – Details from Table 1 [1,000 tonnes] (data from European Commission, 2012)

	Imports From Non-EU-27	Share of Total Imports	Imports From Brazil	Share Brazil of Commodity Imports
Soya cake (in cake equiv.)	30,591.00	29.27 %	13,159.00	43 %
Cereals in animal feed	12,323.00	11.79 %	1,052.00	9 %
Other high protein animal feed	4,984.00	4.77 %	31.00	1 %
Other high energy animal feed	3,519.40	3.37 %	267.80	8 %
Sunflower cake (in gr. equiv.)	2,625.00	2.51 %	12.00	0 %
Molasses	1,877.00	1.80 %	3.00	0 %
Corn gluten feed	979.00	0.94 %	no data	
Manioc	9.60	0.01 %	0.20	2 %

The import of soya into the EU plays a very important role because soya is only marginally planted within the EU at the moment, which is inter alia a consequence of a lack of funding and support with means of the EU or its member countries (Reichert & Reichardt, 2011).

2 Methods

In this chapter, all the methods that were used for this study are described.

2.1 Literature Research

Literature research has been a very important part of this study. At first, of course, the theoretical framework and other necessary information on the topic have been researched in scientific journals, in publications by scientific institutes, groups and networks, in reports by non-governmental and other organisations and e.g. in press releases by the Brazilian government.

The literature was most valuable for finding concrete figures on the research questions such as to what extent is the percentage of deforestation in the Amazon caused by cattle plantations, or how long does a cattle pasture exist on average until it is occupied by soya. It is indicated on all figures where they come from and an attempt has been made to find the most reliable figures possible, by using those that have been cited by more than just one paper.

2.2 Usage of Databases

The trade data used for this study was derived from FAOSTAT, which is the statistical database of the FAO. It says on the website that the current database was published in 2012. However, for some data only values until 2011 or 2010 are available. Therefore just the years from 2000 until 2010 were looked at.

Some of the data was cross-referenced through other databases such as UNCOMTRADE (2013) and the European Commission (2012). More about the comparison can be found in Chapter 3.1.4.

An important note to make is that export, not net export from Brazil, has been used in this paper. Also, for all considered years the EU-27 was used as the import partner in order to keep the years comparable.

The exact commodities that were looked at are “Meat-CattleBoneless(Beef&Veal)”, “Cake of Soybeans” and “Soybeans”.

Soya oil has not been looked at because it makes only 2 % of the EU’s soya imports (WWF UK, 2011), hence the effort to get and edit all this data would have bore no relation to the knowledge gained. So the impacts of the EU are most likely a bit underestimated in this study.

The commodities “Meat of Beef, Drd, Sltd, Smkd” and “Cattle Meat” have not been considered because they are not traded between Brazil and the EU. Other products made from cattle such as milk, leather and a few others have not been taken into account as this would have most likely led to double-counting.

Furthermore, the commodity “Preparations of Beef Meat” has not been considered here because it also includes other components as only 20 % have to be beef meat like described in the FAO definition: “Preparations of Beef Meat = Meat and offal (o / t liver) that are boiled, steamed, grilled, fried, roasted or otherwise cooked. Includes prepared meals that contain more than 20 % of meat and offal by weight” (FAOSTAT, 2013). The omission of this traded commodity which is only vaguely defined prevents this study from overestimating the impact of the EU in deforestation in Brazil. Along with the omission of soya oil as stated above, this paper is therefore more likely to be underestimating its negative effects in the form of deforestation and CO_2-emissions.

2.3 Calculations

The results of this study have been derived through calculations using the data from literature and from the trade statistics. The used equations can be found in the respective subchapters, the most important ones are Equation 4 and Equation 5.

It was not possible to determine exactly how much of the soya that was resulting in deforestation was that which was being exported to the EU. Therefore, all deforestation happening due to a certain commodity has been allocated to an importing country according to its percentage of imported commodity produced in Brazil. Deforestation has been distributed to all importing countries using the same method. If the EU imported only non-deforestation soya or cattle meat, the calculations here overestimate the impacts of the EU. However, if this has been the case, it could not be found out with the given trade data.

Another aspect that needs to be known is that for the calculations related to hypothesis one, the CO_2-emissions from deforestation have been fully allocated to the driver of this deforestation, so cattle meat or soya, in the first year like Reichert & Reichardt (2011) did as well. According to the IPCC (2006) the emissions from land use change should be allocated to all commodities grown on the area over 20 years. However, this is not realisable with the given data and is too complex for this study. Still, for the calculations related to hypothesis two, a reallocation according to the time of occupation of pastures and soya plantations has been done over the past 20 years but just to find out the allocation factor for cattle and soya; the emissions have still been fully allocated to cattle meat and soya in the first year.

3 Results

In this chapter, all gathered data is shown, described and discussed. Furthermore, all calculations that were made are shown and explained in detail.

The chapter is divided into two subchapters concerning the first and the second hypothesis, which are then further subdivided into chapters regarding the different calculation steps. At the end of each subchapter for the hypothesis one and two, the results for the respective hypothesis are presented.

3.1 Hypothesis One

The data collected and the calculations made for hypothesis one within this subchapter are the basis for the second hypothesis.

3.1.1 Data on Deforestation

According to the Global Forest Resources Assessment (FAO, 2010), net deforestation in Brazil climbed from 2,890 million hectares per year in the 1990s to 3,090 million hectares annually between 2000 and 2005. From then on, a decline started, with an average of 2,194 million hectares per year between 2005 and 2010. Even though this was on average only 0.42 % of the remaining forest area annually during this time, it was by far the largest deforested area in the world, followed by less than half (924 million hectares) in Australia where severe droughts and bush fires destroyed a large amount of forest (FAO, 2010).

As mentioned before, most of the deforestation in Brazil happened and still happens in the Amazon and the Cerrado – these two biomes are looked at separately in this study because this is how data is available. It needs to be further noted that the numbers above indicate net deforestation, so adding up the figures for deforestation in the Amazon and the Cerrado given below is more than the total deforestation given here.

Deforestation in the Amazon

The Brazilian National Institute for Space Research (INPE) started measuring and recording deforestation in the Legal Amazon via satellite images in 1988 (MCT Brazil, 2010), the results until 2012 can be seen in Figure 23. Peaks in Amazon deforestation hence happened in the years 1995 and 2004. Until now, already more than 20 % of the original vegetation has been deforested (own calculation, data from Greenpeace, 2006). By area, Brazil has the highest loss of forest in the world – in 2004, an area the size of Belgium was deforested (FAO, 2010; Greenpeace, 2006). 75 % – 80 % of this deforestation was illegal (Greenpeace, 2006; Ibrahim et al., 2010).

Although there is a clearly decreasing trend of Amazon deforestation since 2004, Martins et al. (2012) found in their analysis that deforestation was increasing again in the second half of 2012. However, compared to 2004, this deforestation is still at a low level with less than 5,000 km^2 – even though it was still an area nearly twice the size of the German federal state Saarland. The locations of Amazon deforestation can be seen in Figure 24. It mostly occurs at the frontier of the Amazon and along roads or rivers (Greenpeace, 2009b; Ibrahim et al., 2010).

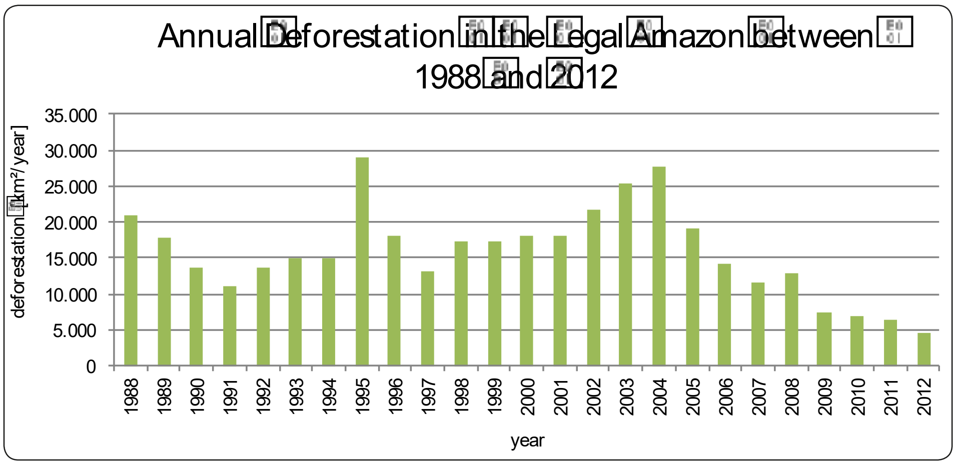


Figure 23: Annual Deforestation in the Legal Amazon between 1988 and 2012 (own figure, data from INPE, 2012)

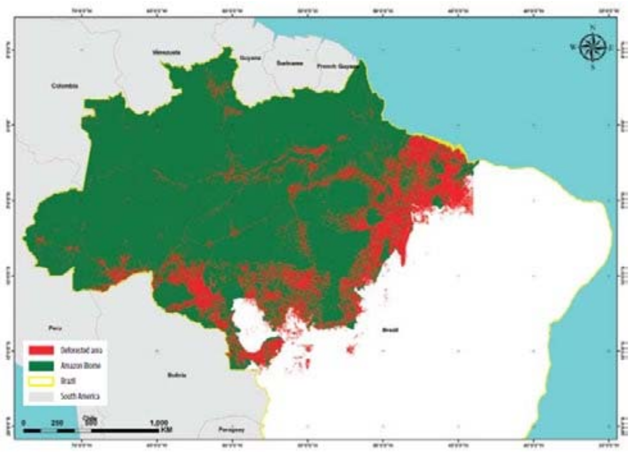


Figure 24: Location of Amazon Deforestation (Greenpeace, 2009b, p. 4, with data from Imazon)

Deforestation in the Cerrado

For deforestation in the Cerrado, there is only reliable data between the years 2002 and 2008 from the government that states a deforestation of 21,000km^2 annually in the Cerrado (Brazilian Government, 2009). This is not only more deforestation than in the Amazon after 2004, but also twice as much in relative numbers: 1.1 % of the vegetation was deforested each year on average (Hance, 2010).

From the original vegetation of the Cerrado, 53 % was left in 2008 (WWF UK, 2011; von Witzke et al., 2011) and in 2010 already 79 % was lost (Hance, 2010; Ibrahim et al., 2010, see Figure 25). This is an area larger than the sizes of Britain, France and Germany together (Pearce, 2012). A slowdown of deforestation is mentioned though by WWF UK (2011).

Figure 25: Deforestation in the Cerrado from 1988 – 2010. Red = Deforested Areas, Green = Natural Landcover (WWF, 2014, p. 45, data from Brazil Ministry of Environment)

3.1.2 Figures for CO_2-emissions

In Brazil's Second National Communication to the UNFCCC (MCT Brazil, 2010), official data for the CO_2-emissions from Land Use Change and Forestry of Brazil, along with more detailed data of the Amazon and of the Cerrado up to 2005, were published. The emissions of the Amazon and the Cerrado make up around 90 % of Brazil's total emissions in this sector and are listed in Table 3 as well as shown in Figure 26 below.

With the area of deforestation as mentioned above and these carbon dioxide emissions, the emissions per hectare could be calculated. For the Amazon, values for the years between 2000 and 2005 were derived; the average is 455.05 t CO_2 / ha. This average value has been taken to calculate the CO_2-emissions until 2010 (see also Table 4). For the Cerrado, an average of 131.13 t CO_2 / ha was calculated for these six years, for which data is available.

Table 3: CO_2-emissions from Land Use Change and Forestry in Brazil, the Amazon and the Cerrado (data from MCT Brazil, 2010)

CO_2-emissions from Land Use Change and Forestry [t]	2000	2001	2002	2003	2004	2005
Brazil Total	1,249,627	1,246,324	1,412,696	1,604,364	1,717,913	1,251,152
Amazon Biome	814,106	810,803	977,175	1,196,179	1,309,729	842,967
Cerrado Biome	302,715	302,715	302,715	275,378	275,378	275,378

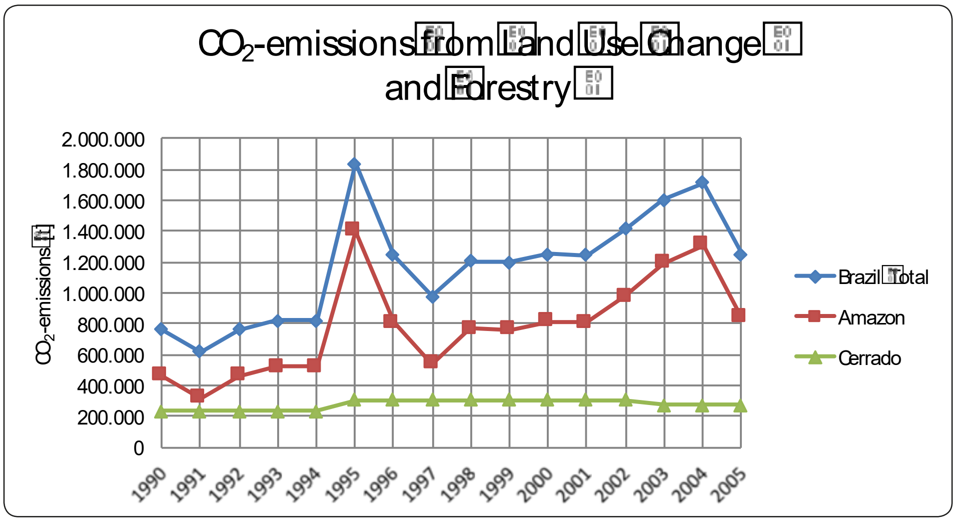


Figure 26: Long-Term CO2-emissions from Land Use Change and Forestry in Brazil Total, the Amazon and the Cerrado (own figure, data from MCT Brazil, 2010)

However, in the literature, different values for CO_2-emissions from Amazon and Cerrado deforestation are given; most of them are higher than the ones mentioned above. This is why, in this study, all results were calculated for the minimum emissions with the factors stated above as well as for the maximum emissions with the factors as stated below.

For the CO_2-emissions of the Amazon, Greenpeace (2009a) cites Saatchi et al. (2007) who calculated 150 tonnes of carbon per hectare. The conversion factor from carbon to carbon dioxide is 3.667 (see Equation 1) and can be derived from the molecular weight difference of these two molecules: Carbon has a molecular weight of 12 grams per mole and carbon dioxide has a molecular weight of 44 grams per mol. To convert the 12 grams to 44 grams, a factor of 3.667 is needed.

Equation 1: Conversion of Carbon to Carbon Dioxide

$$mass\ of\ CO_2 = mass\ of\ C \times 3.667$$

This means for the estimation of Saatchi et al. (2007) emissions of 550.05 t CO_2 / ha. Fargione et al. (2008) even give a value of 737 t CO_2 / ha when Amazon rainforest is converted to cropland. This estimation is taken as the maximum value for the Amazon.

For the CO_2-emissions of the Cerrado, the data from Fargione et al. (2008) has also been taken. They calculated 165 t CO_2 / ha when wooded Cerrado is converted to cropland and 85 t CO_2 / ha when grassland savannah is transformed. As can be seen in Figure 19, about 90 % of the Cerrado is wooded and about 10 % is not (data from FAO, 2009). That is why the CO_2-emissions were distributed accordingly (see Equation 2).

Equation 2: Estimation of the Maximum Cerrado CO_2-emissions from Deforestation with Data from Fargione et al. (2008) and FAO (2009)

$$Average\ Cerrado\ CO_2 - emissions = 165\ \frac{t\ CO_2}{ha} \times 90\% + 85\ \frac{t\ CO_2}{ha} \times 10\% = 157\ \frac{t\ CO_2}{ha}$$

To sum it up, all values are shown in Table 4 for the Amazon and Table 5 for the Cerrado. In these tables, the absolute emissions from deforestation between 2000 and 2010 can be found as well.

Table 4: CO_2-emissions from Amazon Deforestation (data from INPE, 2012; MCT Brazil, 2010; Fargione et al., 2008 and own calculations)

	Deforestation [ha]	Minimum Figure t CO_2 / ha	Minimum CO_2-emissions [t]	Maximum Figure t CO_2 / ha	Maximum CO_2-emissions [t]
2000	1,822,600	446.67	814,106,000	737	1,343,256,200
2001	1,816,500	446.35	810,803,000	737	1,338,760,500
2002	2,165,100	451.33	977,175,000	737	1,595,678,700
2003	2,539,600	471.01	1,196,179,000	737	1,871,685,200
2004	2,777,200	471.60	1,309,729,000	737	2,046,796,400
2005	1,901,400	443.34	842,967,000	737	1,401,331,800
2006	1,428,600	455.05	650,084,430	737	1,052,878,200
2007	1,165,100	455.05	530,178,755	737	858,678,700
2008	1,291,100	455.05	587,515,055	737	951,540,700
2009	746,400	455.05	339,649,320	737	550,096,800
2010	700,000	455.05	318,535,000	737	515,900,000

Table 5: CO_2-emissions from Cerrado Deforestation (data from Brazilian Government, 2009; MCT Brazil, 2010; Fargione et al., 2008 and own calculations)

	Deforestation [ha]	Minimum Figure t CO_2 / ha	Minimum CO_2-emissions [t]	Maximum Figure t CO_2 / ha	Maximum CO_2-emissions [t]
2002	2,308,511	131.13	302,715,000	157	362,436,170
2003	2,100,000	131.13	275,373,000	157	329,700,000
2004	2,100,000	131.13	275,373,000	157	329,700,000
2005	2,100,000	131.13	275,373,000	157	329,700,000
2006	2,100,000	131.13	275,373,000	157	329,700,000
2007	2,100,000	131.13	275,373,000	157	329,700,000
2008	2,100,000	131.13	275,373,000	157	329,700,000

3.1.3 Proportions that are Converted to Pasture and Soya

One of the most important and also difficult parts of this study was to find out how much deforestation in the Amazon and the Cerrado happened due to cattle pastures and how much happened due to soya plantations. The findings are listed below:

For the conversion of the Amazon to cattle pastures, 80 % is taken. This value is given by the Brazilian government (Presidência da República, 2004, p. 10) and furthermore stated in Chomitz & Thomas (2001). For the conversion of the Cerrado to cattle pastures, 68 % is estimated. This value was derived from the Woods Hole Research Center (2013) in accordance with Klink & Moreira (2002, p. 81).

For the conversion of Amazon and Cerrado to soya plantations, the figures given by Macedo et al. (2012) have been used which are very close to the figures in Morton et al. (2006). Macedo et al. (2012) give figures for each year between 2001 / 2003 and 2010. In Figure 27, the proportion of cropland – which is nearly entirely soya – following deforestation in the Amazon in the state of Mato Grosso can be seen. The respective values are displayed in Table 6. For 2010, where no conversion to cropland but only to "unknown" is given, the value of 2009 was taken.

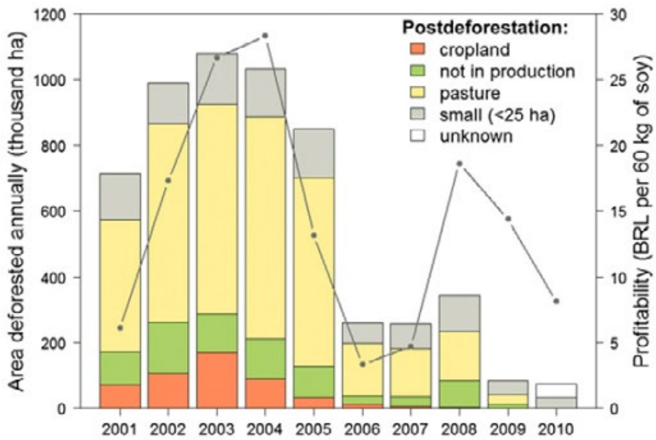


Figure 27: Land Use After Amazon Deforestation in Mato Grosso (Macedo et al., 2012, p. 1343, © PNAS)

The proportion which is deforested in the Cerrado for cropland can be seen in Figure 28 (third figure) and as well in Table 6. For the years from 2000 until 2002 the value of 2003 was taken.

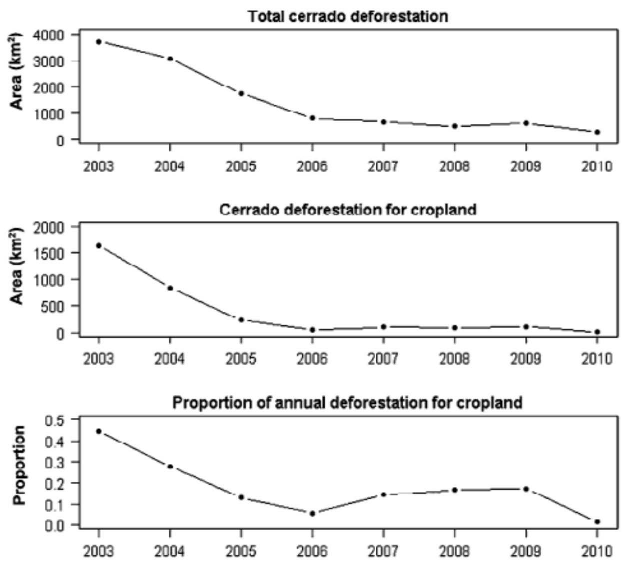


Figure 28: Proportion of Cerrado Deforestation in Mato Grosso which is due to Cropland Expansion, see the Third Figure (Macedo et al., 2012, Supporting Information, p. 5, © PNAS)

Table 6: Proportion of Soya Plantations Following Deforestation in the Amazon and the Cerrado in the State of Mato Grosso (partly own estimations, data from Macedo *et al*., 2012)

	Amazon	Cerrado
2000	10.0%	30.0%
2001	10.4%	30.0%
2002	11.1%	30.0%
2003	18.5%	44.0%
2004	8.8%	28.0%
2005	3.5%	13.0%
2006	3.8%	8.0%
2007	1.9%	15.0%
2008	2.0%	17.0%
2009	1.0%	18.0%
2010	1.0%	3.0%

However, not these annual values are used but averages for the first six years (from 2000 until 2005) and for the last five years of the decade (from 2006 until 2010). Macedo *et al.* (2012) describe in their paper, that these two time periods can be told apart from each other. This is not only due to the fact that deforestation in Mato Grosso decreased dramatically between 2005 and 2006 but also because the relative importance of soya as a driver of deforestation decreased from 10% to 2% in the Amazon and from 29% to 12% in the Cerrado.

The reasons for these decreases were at first stricter laws to control deforestation, secondly the soya moratorium in 2006 which ruled out soya grown on deforested areas from the supply chains of many soya trading companies, thirdly the fact that soya occupied active or degraded pastures more and more from the middle of the decade on, thus its direct influence on deforestation decreased and fourthly that another driver of deforestation gained importance: sugar cane cultivation to produce bioethanol (Macedo *et al*., 2012; Ibrahim *et al*., 2010).

The figures taken and the data sources for them can all be seen in the overview in Table 7 below:

Table 7: Overview of Figures Taken for the Proportions of Soya and Pasture in Deforestation of the Amazon and the Cerrado with Data Sources

Amazon	To Pasture	To Soya Plantations	Data Source
2000–2005	80%	10%	Presidência da Repúbica (2004) and Chomitz & Thomas (2001) / own calculation, data from Macedo *et al.* (2012)
2006–2010	80%	2%	
Cerrado			
2000–2005	68%	29%	WHRC (2013) and Klink & Moreira (2002) / own calculation, data from Macedo *et al.* (2012)
2006–2010	68%	12%	

3.1.4 Production and Trade Data – Cattle Meat

According to the FAOSTAT database, the pasture area in Brazil did not change much within the last decade. At the same time, the number of cattle increased from approximately 170 million in 2000 to nearly 210 million in 2010 (FAOSTAT, 2012). This can be explained by an increase in cattle density throughout the country. In the Amazon, the cattle density is higher than one head per hectare since a few years now and in the Cerrado, it was 0.96 head per hectare in 2006 (IBGE, 2007). More about the development of cattle numbers and cattle density can be found in Chapter 3.2.

For the further analysis, the production quantities of cattle meat in Brazil in the last decade have been looked up. Furthermore, the export quantities of this cattle meat from Brazil have been figured out in total and for exports to the EU. Then, the proportions of the exported meat in total and to the EU from the total production could be calculated. The results can be seen in Table 8.

Table 8: Overview of Production as well as Export Quantities and Proportions Concerning Cattle Meat in / from Brazil (own calculations, data from FAOSTAT, 2012)

	Production [t]	Export Total [t]	% Exported Total	Export to EU [t]	% Exported to EU
2000	6,578,800	269,146	4 %	146,294	2.22 %
2001	6,823,600	525,456	8 %	178,990	2.62 %
2002	7,139,000	614,044	9 %	182,786	2.56 %
2003	7,230,000	885,064	12 %	232,993	3.22 %
2004	7,774,000	1,319,513	17 %	319,170	4.11 %
2005	8,592,000	1,548,476	18 %	420,454	4.89 %
2006	9,020,000	1,745,287	19 %	448,556	4.97 %
2007	9,303,000	1,830,389	20 %	279,293	3.00 %
2008	9,024,000	1,454,084	16 %	54,636	0.61 %
2009	9,395,000	1,318,126	14 %	66,710	0.71 %
2010	9,115,000	1,353,799	15 %	64,429	0.71 %

It has to be noted that the exported meat was given as boneless in the FAOSTAT database. According to von Witzke et al. (2011, p. 50), boneless meat makes up approximately 70 % of the carcass weight of meat, so to compare the data and to get appropriate proportions, the exported boneless meat was converted into carcass weight with a factor of 100 / 70. The calculation method can be seen in Equation 3.

Equation 3: Conversion of Cattle Meat Given in Boneless Weight into Carcass Weight

$$carcass\ weight\ =\ boneless\ weight \times \frac{100}{70}$$

The data of exports from Brazil to the EU have been compared with import data of the EU from the European Commission (2012) and UNCOMTRADE (2013) and are very similar although export and import values are never exactly the same. This fact is also due to different categories of the databases because for example in the EU statistics, also live animals are included. The comparison of the trade data of the different databases has been done for cattle meat as well as for soya beans and cake and the result is that the export values from FAOSTAT (2012) match with those of the European Commission and UNCOMTRADE with one exception: the data from UNCOMTRADE for the EU's imports of flours and meals of soya beans (UN COMTRADE item code 120810) are quite implausible because they are very erratic, jumping from 9 tonnes to more than 1,000 tonnes in just one year, and do not match with the ones from FAOSTAT and the European Commission. Probably the item that was looked at is just a fraction of the soya cake imports of the EU from Brazil but within the UNCOMTRADE database, no other matching soya cake item was found. That is why the data from FAOSTAT (2012) for cake of soya beans, matching at least with that of the European Commission, has been taken.

To get a visual impression of how the production of cattle meat developed in Brazil as well as how the export quantities in total and to the EU progressed, Figure 29 has been created (see below).

It can be seen that the production of cattle meat increased quite a lot within the decade and that also the export quantity increased until 2006 / 2007. This increase in exports is a consequence of tariff reductions on agricultural products that came with the foundation of the WTO in 1995 and from that point on slowly liberated trade and led to an increase of exports and imports (Misereor, 2013).

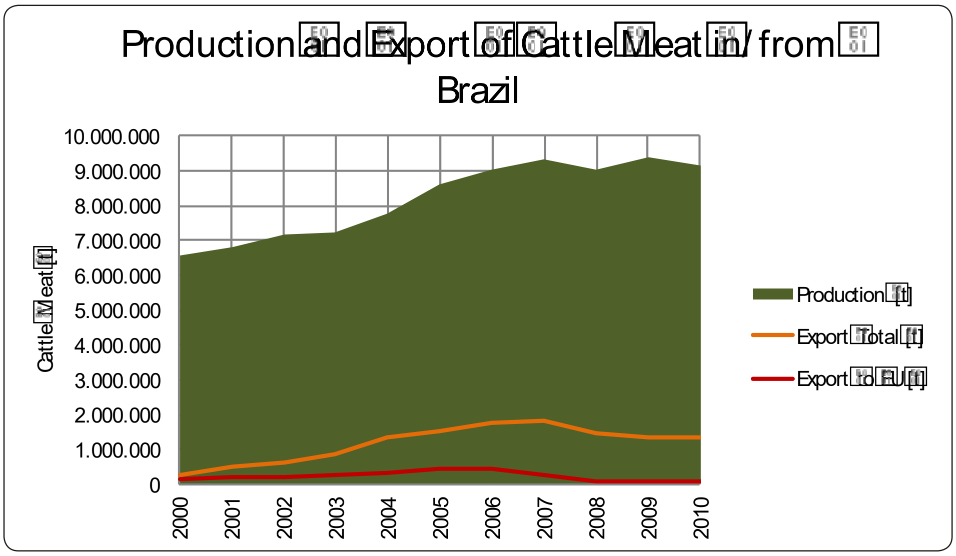


Figure 29: Production and Export of Cattle Meat in/from Brazil (own figure, data from FAOSTAT, 2012)

However, from 2007 on, there was a decline in exports going together with a decline in imports by the EU: In 2006, the EU was importing 26 % of all Brazilian exports of cattle meat and in 2008 only 4 % (see Table 40 and Table 41 in the appendix). The quite drastic decline of the exports to the EU after 2006 can also be seen in detail in Figure 30. This development is most likely a consequence of foot-and-mouth disease (FMD) in Brazil. In 2007, an outbreak of FMD was the reason that the EU established import restrictions and in early 2008 a total ban of imports of Brazilian cattle meat. Only 2 months later cattle meat from some disease-free farms was allowed to be imported again (Ibrahim et al., 2010; Der Europäische Bürgerbeauftragte, 2010; Phillips, 2008; Wochenblatt, 2008). The aim of the Brazilian government now is to make Brazil FMD-free until 2014 (GlobalMeatNews, 2013).

Due to this and also the fact that the quota for tax-reduced and good quality Brazilian cattle meat which can be imported into the EU increased in 2009 as a consequence of the enlargement of the EU (agrarheute, 2009), it can be expected that the import quantity of Brazilian cattle meat which goes into the EU will increase in the coming years again, probably to the same levels as before the FMD-crisis and the import ban, that would mean to about 4.66 % which is the average of 2004 – 2006.

A detailed look at the importers of Brazilian cattle meat has been done and will be presented in the following: As can be derived from Table 8 already (see above), in 2000 the EU imported more than half the Brazilian cattle meat exports and was thus on rank one among the importers. In this year, they imported nearly as much as 300,000 cattle if the imported amount of boneless meat was converted into living animals (own calculation, data from von Witzke et al., 2011, p. 51). The EU held this rank until 2004 when the Russian Federation climbed to the top rank of impor-

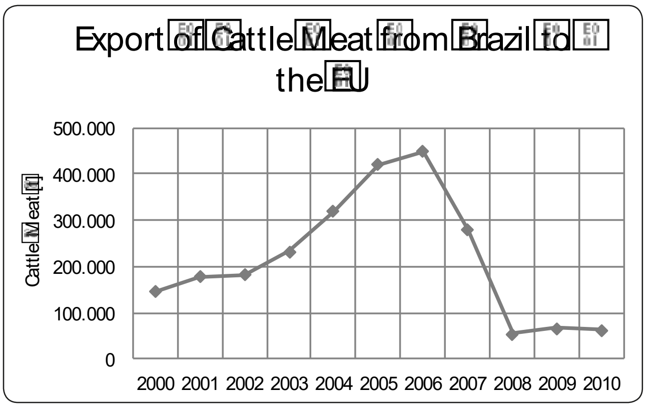


Figure 30: Detailed Development of Brazilian Exports of Cattle Meat to the EU between 2000 and 2010 (own figure, data from FAOSTAT, 2012)

ters. The EU was rank two until 2007, in 2008 it was on rank 7 for the reason of an FMD outbreak and import restrictions as explained above. In 2010 it was on rank five and imported more than 130,000 cattle – if the meat quantity was converted. The ten largest importers in 2010 and their import quantities can be seen in Figure 31; a list with all importing countries of Brazilian cattle meat including their import quantities and percentages for different years can be found in Table 40, Table 41 and Table 42 in the appendix.

Within the EU, the Netherlands, Italy and Germany are the largest importers.

The data which was used for the further calculations is displayed in Table 9. Besides the EU also China and the Russian Federation have been looked at because they are either large importers of soya (China) or cattle meat (Russia). Still, for Russia only values for the years 2006 and 2008 have been calculated. Like this, the impacts of the different countries on deforestation in Brazil before and after the FMD-outbreak can be compared. The export quantities from Brazil to China and the Russian Federation, which are needed to get the proportions of Brazilian cattle meat that was exported to these countries, can be found in Table 43 in the appendix.

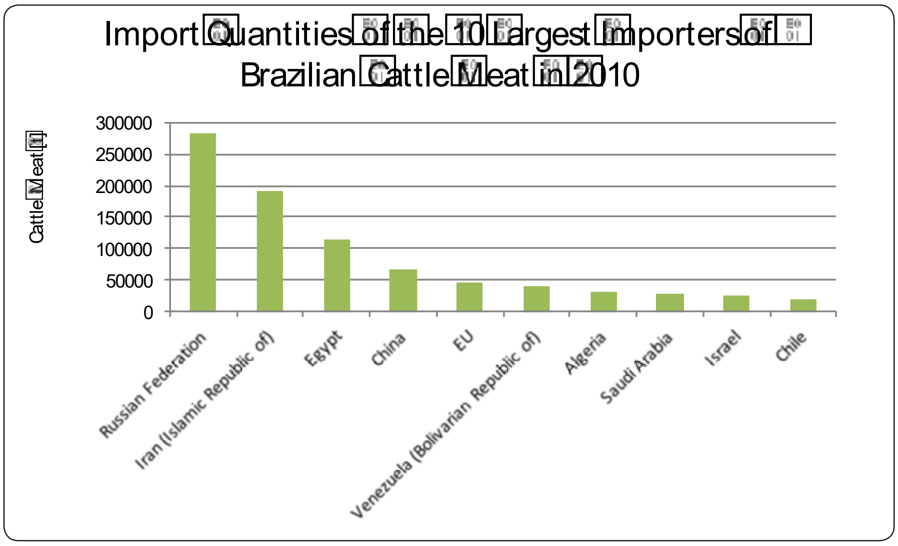


Figure 31: Import Quantities of the 10 Largest Importers of Brazilian Cattle Meat in 2010 (own figure, data from FAOSTAT, 2012)

Table 9: Percentages of Cattle Meat Production in Brazil that are Imported to the EU, to China and to Russia (own calculations, data from FAOSTAT, 2012)

	% cattle meat import of the EU from Brazil	% cattle meat import of China from Brazil	% cattle meat import of Russia from Brazil
2000	2.22 %	0.25 %	
2001	2.62 %	0.31 %	
2002	2.56 %	0.28 %	
2003	3.22 %	0.39 %	
2004	4.11 %	0.43 %	
2005	4.89 %	0.37 %	
2006	4.97 %	0.43 %	5.03 %
2007	3.00 %	0.62 %	
2008	0.61 %	1.01 %	6.05 %
2009	0.71 %	1.55 %	
2010	0.71 %	1.05 %	

3.1.5 Production and Trade Data – Soya

The area in Brazil where soya is grown has more than doubled between 1996 and 2011 (see Figure 32). In 2011, soya plantations covered 9 % of Brazil's total agricultural area (own calculation, data from FAOSTAT, 2012).

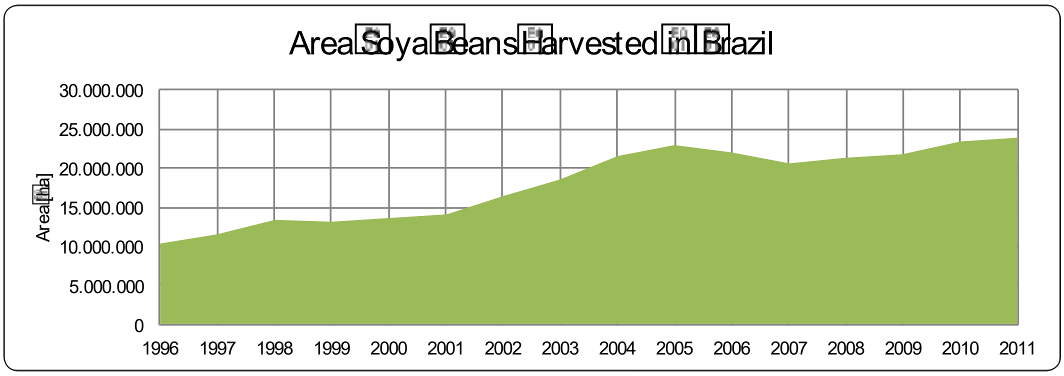


Figure 32: Soya Area Harvested in Brazil from 1996 until 2011 (own figure, data from FAOSTAT, 2012)

The production of soya beans has even increased to a larger extent: it has more than doubled between 2000 and 2010 (see also Table 10 and Figure 33).

The increase in soya bean production which comes not only from an expansion in harvested area is due to intensification of production on the same area and gains in yield (Macedo et al., 2012). The reduction in exports in some years might be a reason of price fluctuations for soya on the international markets; Macedo et al. (2012), Morton et al. (2006) and Greenpeace (2009b) describe in their studies that soya production, hence also export, is very dependent from the price.

As can be seen in Table 10 and Table 11 below, the export quantities of soya beans and soya cake have been determined using data from FAOSTAT. For total exports of soya, these two commodities can just be added up. In comparison to cattle meat it can be seen that soya is much more used as an export good because on average 66 % of the total production has been exported during the regarded time.

Table 10: Overview of Production as well as Export Quantities and Proportion Concerning Soya Beans and Cake in / from Brazil (own calculations, data from FAOSTAT, 2012)

	Production of Soya Beans [t]	Export of Soya Beans [t]	Export of Cake of Soya Beans [t]	Export Total [t]	% Exported Total
2000	32,735,000	11,517,260	9,389,189	20,906,449	64 %
2001	39,058,000	15,675,543	11,270,730	26,946,273	69 %
2002	42,769,000	15,970,003	12,517,154	28,487,157	67 %
2003	51,919,400	19,890,467	13,602,159	33,492,626	65 %
2004	49,549,900	19,247,690	14,485,622	33,733,312	68 %
2005	51,182,100	22,435,072	14,421,680	36,856,752	72 %
2006	52,464,600	24,957,975	12,332,351	37,290,326	71 %
2007	57,857,200	23,733,776	12,474,183	36,207,959	63 %
2008	59,833,100	24,499,491	12,287,896	36,787,387	61 %
2009	57,345,400	28,562,707	12,252,991	40,815,698	71 %
2010	68,756,300	25,860,785	13,668,599	39,529,384	57 %

Table 11: Export Quantities of Soya Beans and Cake to the EU, Absolute and as Proportion of the Brazilian Production of Soya Beans (own calculations, data from FAOSTAT, 2012)

	Export of Soya Beans to the EU [t]	Exports of Cake of Soya Beans to the EU [t]	Export to the EU Total [t]	% Exported to EU Total
2000	7,344,328	7,620,075	14,964,403	46 %
2001	9,786,562	9,581,363	19,367,925	50 %
2002	9,232,262	9,792,468	19,024,730	44 %
2003	10,693,689	10,182,267	20,875,956	40 %
2004	9,184,709	10,951,156	20,135,865	41 %
2005	10,985,647	10,259,782	21,245,429	42 %
2006	9,935,501	8,254,265	18,189,766	35 %
2007	9,726,694	8,803,948	18,530,642	32 %
2008	8,909,875	9,263,238	18,173,113	30 %
2009	8,664,455	8,699,434	17,363,889	30 %
2010	5,870,063	9,474,479	15,344,542	22 %

In the following Figure 33, all trends of production and export can be seen clearly.

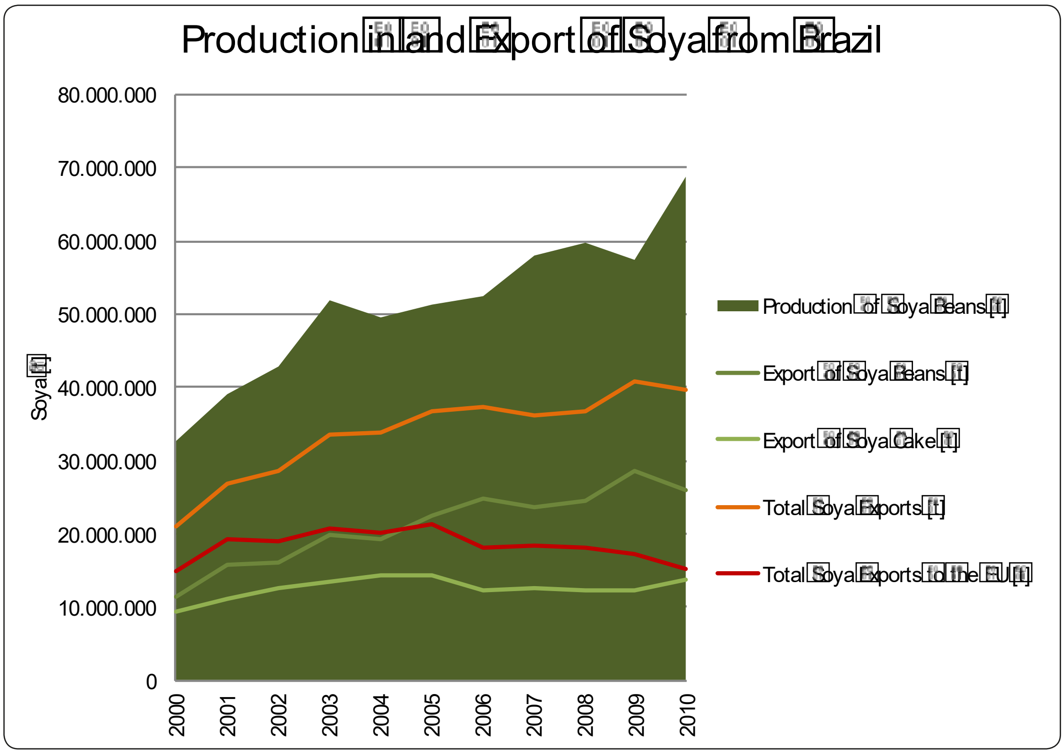


Figure 33: Production of Soya Beans and Export of Soya Beans and Cake in/from Brazil (own figure, data from FAOSTAT, 2012)

The increase of exports from Brazil can be explained through international trade liberalisation and tariff reductions demanded by WTO-rules. Furthermore, a regional reason of the EU for the increase is that soya got a more important ingredient of animal feed after the BSE outbreak and the EU's ban of processed animal protein within animal feed in 2000 (WWF UK, 2011).

The decrease in soya imports of the EU starting in 2006 can be attributed to the fact that in the EU more and more crops usable as biofuels are demanded and grown – also rapeseed. After the extraction of the oil, the cake of rapeseed can be used as animal feed, so soya has been partly replaced by cake of rapeseed since a few years leading to this decrease in imports of soya (Mack, 2010).

Having a closer look at the Brazilian exports of soya beans, it can be seen that the EU and China are the main importers. The EU was on rank one, importing most of the Brazilian soya beans, from 2000 until 2005. Since 2006, China is the main importer with 64 % and the EU on rank two, importing 23 % of Brazil's soya bean exports in 2010. Other importing countries like Thailand or Japan import much less than China and the EU (see Figure 34). A list with all importing countries of Brazilian soya beans including their import quantities and percentages for different years can be found in Table 44, Table 45 and Table 46 in the appendix.

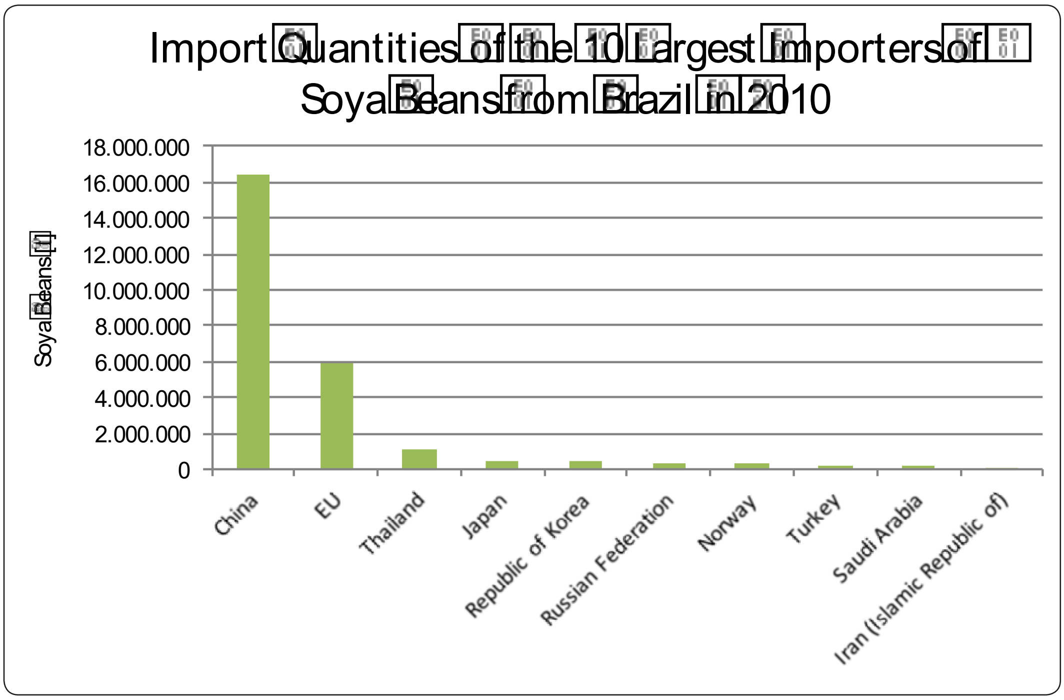


Figure 34: Import Quantities of the Ten Largest Importers of Soya Beans from Brazil in 2010 (own figure, data from FAOSTAT, 2012)

Within the EU, the main importing countries are Spain, the Netherlands and Portugal.

Now, looking at the Brazilian exports of cake of soya beans, from which 79 % is used as animal feed (von Witzke **et al.**, 2011), it can be seen that the EU has been the largest importer within at least the last decade. It imported on average 74 % of the Brazilian exports of cake of soya beans in these years, the largest importers within the EU were the Netherlands, France and Germany.

China does not play an important role as a cake of soya beans importer: it was on rank 23 in 2009; for 2010 no data was available on FAOSTAT. Other importers are shown in Figure 35 but they import much less than the EU. A list with all importing countries of Brazilian cake of soya beans including their import quantities and percentages for different years can be found in Table 47, Table 48 and Table 49 in the appendix.

The area used in Brazil to grow all soya (for beans and cake) exported annually to the EU is approximately 6 million hectares, taken a productivity of 3 tonnes of soya beans per hectares as proposed by WWF UK (2011, p. 13). This is the area of Brandenburg, Thuringia and Schleswig-Holstein together.

The data which was used for the further calculations is displayed in Table 12.

For Russia, no values have been calculated because it plays a very minor role in importing soya from Brazil. In 2010, it imported 2 % of Brazil's soya bean export (so 0.6 % of Brazil's total production), in 2008 1 % of the exported beans and for all other years either 0 % or no data was available.

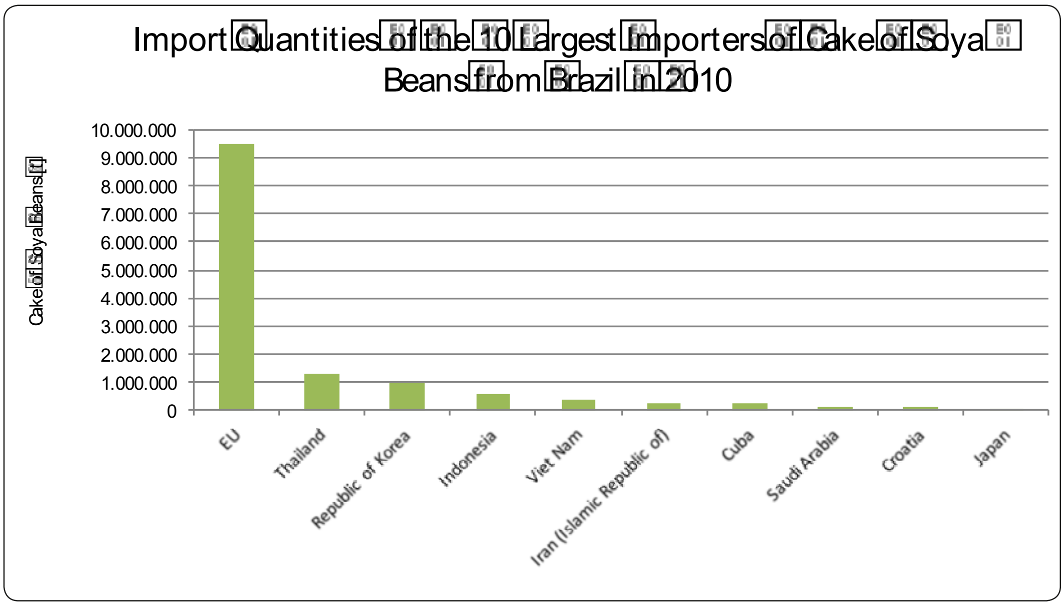


Figure 35: Import Quantities of the Ten Largest Importers of Cake of Soya Beans from Brazil in 2010 (own figure, data from FAOSTAT, 2012)

Concerning cake of soya beans Russia imported between 1% and 0% of Brazilian exports (own calculations, data from FAOSTAT, 2012). Thus these quantities are so low that they can be neglected in this study.

The export quantities from Brazil to China, which are needed to get the proportions of Brazilian soya that was exported to China, can be found in Table 50 in the appendix.

Table 12: Percentages of Soya Production in Brazil that are Imported to the EU and China (own calculations, data from FAOSTAT, 2012)

	% soya import of the EU from Brazil	% soya import of China from Brazil
2000	46%	6%
2001	50%	9%
2002	44%	10%
2003	40%	13%
2004	41%	13%
2005	42%	15%
2006	35%	22%
2007	32%	18%
2008	30%	20%
2009	30%	29%
2010	22%	24%

3.1.6 CO_2-emissions for the EU's Imports of Cattle Meat

To calculate the CO_2-emissions for the EU's imports of cattle meat and also for its imports of soya (described below), Equation 4 was developed and used:

Equation 4: Calculation of the CO_2-emissions of an Exported Commodity (own equation)

$$
\begin{aligned}
&CO_2 - emissions\ of\ an\ exported\ commodity \\
&\quad = CO_2 \\
&\quad - emissions\ \ from\ deforestation\ (in\ a\ certain\ biome) \\
&\quad \times\%\ of\ deforestation\ in\ this\ biome\ due\ to\ the\ commodity \\
&\quad \times\%\ of\ the\ commodity\ exported\ to\ the\ country\ of\ interest
\end{aligned}
$$

The annual emissions from deforestation of the Amazon and the Cerrado, as displayed in Table 4 and Table 5, were taken at first. Due to the fact that these CO_2-emissions varied within the different literature sources, minimum and maximum values are given for most of the results below.

The data taken for percentage of deforestation in the Amazon and the Cerrado due to Cattle Meat and Soya can be found in Table 7, and in Table 9, the needed figures for the EU's import proportions of cattle meat from Brazil are listed in Table 9.

The first results are shown in Table 13: In 2004, when there was a peak in deforestation of the Amazon and hence of CO_2-emissions, between 43 and 67 million tonnes of the emitted CO_2 or 3% can be assigned to cattle meat imported into the EU. With decreasing deforestation and cattle meat imports of the EU until 2010, this value also decreased, in absolute and partly in relative numbers.

Table 13: CO_2-emissions from Amazon deforestation through the EU's Import of Cattle Meat (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Cattle Meat, Min [t]	% of Amazon Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Cattle Meat, Max [t]	% of Amazon Deforestation Emissions, Max
2000	14,482,770	2%	23,896,237	2%
2001	17,014,553	2%	28,093,645	2%
2002	20,015,535	2%	32,684,384	2%
2003	30,838,303	3%	48,253,309	3%
2004	43,017,875	3%	67,226,757	3%
2005	33,000,846	4%	54,859,959	4%
2006	25,862,533	4%	41,886,877	4%
2007	12,733,581	2%	20,623,268	2%
2008	2,845,693	0%	4,608,875	0%
2009	1,929,374	1%	3,124,807	1%
2010	1,801,235	1%	2,917,275	1%

In the Cerrado, the deforestation did not decrease until 2008 but due to less imports of cattle meat of the EU from 2007 on, it did not really contribute much to Cerrado deforestation from then on. However, the cattle meat which was exported to the EU led to up to 3% of deforestation in the Cerrado in some years; see Table 14.

Table 14: CO_2-emissions from Cerrado Deforestation through the EU's Import of Cattle Meat (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Cattle Meat, Min [t]	% of Cerrado Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Cattle Meat, Max [t]	% of Cerrado Deforestation Emissions, Max
2002	5,270,450	2%	6,310,232	2%
2003	6,034,516	2%	7,224,905	2%
2004	7,688,041	3%	9,204,610	3%
2005	9,163,527	3%	10,971,156	3%
2006	9,312,108	3%	11,149,046	3%
2007	5,621,794	2%	6,730,769	2%
2008	1,133,746	0%	1,357,392	0%

The EU's share in total deforestation emissions in Brazil through its imports of cattle meat can be seen in Table 15. It was responsible for up to 3.84% of total deforestation emissions in Brazil in the year 2006, just before the imports of cattle meat of the EU decreased. In the last year possible to calculate, the share had dropped to 0.47%.

Table 15: CO_2-emissions from Deforestation in Brazil through the EU's Import of Cattle Meat (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Cattle Meat, Min [t]	% of Total Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Cattle Meat, Max [t]	% of Total Deforestation Emissions, Max
2002	25,285,985	1.98%	38,994,616	1.99%
2003	36,872,819	2.51%	55,478,215	2.52%
2004	50,705,916	3.20%	76,431,366	3.22%
2005	42,164,373	3.77%	65,831,115	3.80%
2006	35,174,641	3.80%	53,035,923	3.84%
2007	18,355,376	2.28%	27,354,037	2.30%
2008	3,979,438	0.46%	5,966,267	0.47%

3.1.7 CO_2-emissions for the EU's Imports of Soya

In Table 12, the needed percentages for soya exported to the EU which was needed for the following calculations can be found.

The Amazon deforestation emissions from the EU's soya imports can be found in Table 16 and the EU's Cerrado deforestation emissions in Table 17.

Table 16: CO_2-emissions from Amazon Deforestation through the EU's Import of Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Soya, Min [t]	% of Amazon Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Soya, Max [t]	% of Amazon Deforestation Emissions, Max
2000	37,215,855	5%	61,405,307	5%
2001	40,205,775	5%	66,385,921	5%
2002	43,467,209	4%	70,979,813	4%
2003	48,096,434	4%	75,257,453	4%
2004	53,224,177	4%	83,176,789	4%
2005	34,991,131	4%	58,168,569	4%
2006	4,507,772	1%	7,300,774	1%
2007	3,396,150	1%	5,500,393	1%
2008	3,568,932	1%	5,780,231	1%
2009	2,056,888	1%	3,331,329	1%
2010	1,421,772	0%	2,302,698	0%

Table 17: CO_2-emissions from Cerrado Deforestation through the EU's Import of Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Soya, Min [t]	% of Cerrado Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Soya, Max [t]	% of Cerrado Deforestation Emissions, Max
2002	39,050,028	13%	46,754,018	13%
2003	32,110,269	12%	38,444,450	12%
2004	32,452,992	12%	38,854,780	12%
2005	33,149,321	12%	39,688,469	12%
2006	11,457,008	4%	13,717,057	4%
2007	10,583,847	4%	12,671,652	4%
2008	10,036,870	4%	12,016,777	4%

The quite obvious change from 5%/4% to 1%/0% in the Amazon and from 13/12% to 4% in the Cerrado can be explained through the fact that soya was not such an important direct driver of deforestation in the second half of the decade and expanded more on pastures than into the forest.

The EU's share in total deforestation emissions in Brazil through its imports of soya can be seen in Table 18 and ranges from 6.45% in 2002 to 1.39% in 2008.

Table 18: CO_2-emissions from Deforestation in Brazil through the EU's Import of Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports of Soya, Min [t]	% of Total Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports of Soya, Max [t]	% of Total Deforestation Emissions, Max
2002	82,517,236	6.45%	117,733,831	6.01%
2003	80,206,704	5.45%	113,701,903	5.17%
2004	85,677,169	5.41%	122,031,569	5.13%
2005	68,140,452	6.09%	97,857,038	5.65%
2006	15,964,781	1.73%	21,017,830	1.52%
2007	13,979,996	1.74%	18,172,046	1.53%
2008	13,605,802	1.58%	17,797,008	1.39%

3.1.8 Total CO_2-emissions of the EU's Imports

The last calculation to find out about the EU's deforestation emissions in Brazil from its import of cattle meat and soya was to add up the emissions from all steps. See the results in Table 19.

Table 19: Total CO_2-emissions from Deforestation in Brazil through the EU's Import of Cattle Meat and Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to the EU's Imports, Min [t]	% of the EU's Emissions of Total Deforestation Emissions, Min	CO_2-emissions due to the EU's Imports, Max [t]	% of the EU's Emissions of Total Deforestation Emissions, Max
2002	107,803,222	8%	156,728,447	8%
2003	117,079,523	8%	169,180,117	8%
2004	136,383,085	9%	198,462,936	8%
2005	110,304,826	10%	163,688,153	9%
2006	51,139,422	6%	74,053,753	5%
2007	32,335,372	4%	45,526,082	4%
2008	17,585,241	2%	23,763,275	2%

In 2005, the EU was responsible for more than 110 million tonnes of CO_2, hence 10% of total deforestation in Brazil with its imports. In 2008, this amount decreased to 17 million tonnes which was a share of 2% of deforestation in Brazil.

In Figure 36 the contributions of cattle meat and soya can be seen clearly for each year: The decrease in soya contribution can be explained by the fact that soya was less responsible for deforestation in the second half of the decade. The decrease in cattle meat contribution which is mostly responsible for the relative increase in soya contribution to total emissions, can be explained by the export restrictions and bans of the EU for cattle meat from 2007 onwards.

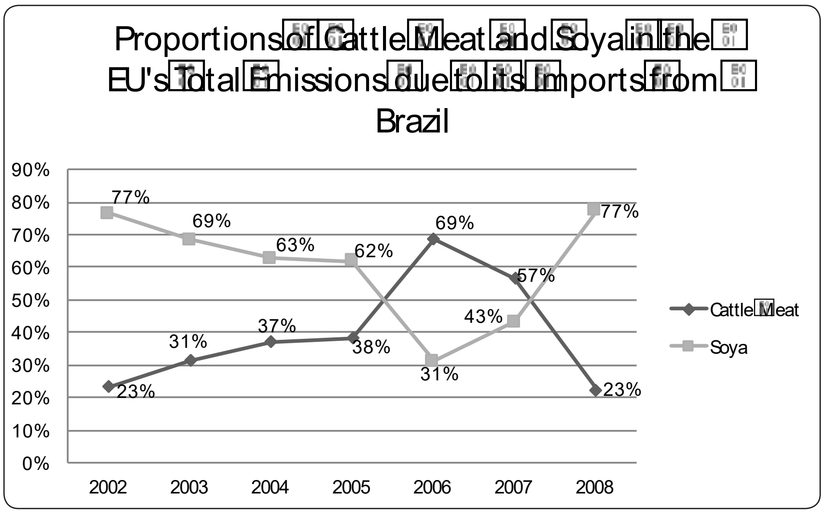


Figure 36: Proportions of Cattle Meat and Soya in the EU's Total Emissions due to its Imports from Brazil (own figure and calculations, data from FAOSTAT, 2012)

For all years, the total CO_2-emissions of the EU have been looked up in Eurostat (2013). On average, it have been nearly five billion tonnes of CO_2-equivalent. Thus, the emissions in Brazil, the EU was responsible for in 2008, the last year of the calculations, represent nearly 0.5% of additional emissions for the EU. The year with the highest share was 2004 with the additional emissions making up 3.8% of the EU's total emissions (see also Table 20). Taking the EU's emissions from agriculture, hunting, forestry and fishing in 2008 (see also Figure 37), which accounted to more than 670 million tonnes of CO_2-equivalent, it can be calculated that the emissions caused by the EU in Brazil are an additional 3.5% to the domestic ones.

Table 20: Percentages of the Additional CO_2-emissions of the EU Caused in Brazil of its Total Domestic and Agricultural Emissions for 2004 and 2008 (data from Eurostat, 2012 and 2013 as well as FAOSTAT, 2012)

	Total Emissions of the EU [CO_2-equivalent]	% of the Additional Emissions	EU Emissions from Agriculture, Hunting, Forestry & Fishing [CO_2-equivalent]	% of the Additional Emissions
Min. 2004	5,177,932,000	2.63 %		
Max. 2004		3.83 %		
Min. 2008	4,974,387,000	0.35 %	676,516,632	2.60 %
Max. 2008		0.48 %		3.51 %

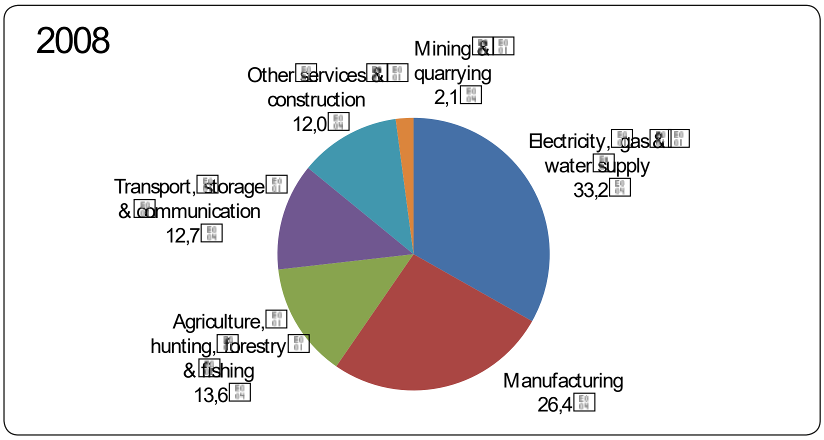


Figure 37: Greenhouse Gas Emissions of the EU by Sector in 2008 [CO2-equivalent] (own figure, based on Eurostat, 2012)

In the following, the impact of the EU on deforestation emissions in Brazil will be compared with those of other countries, namely China and Russia because they are the two other major importers of either cattle meat (Russia) or soya (China).

3.1.9 CO_2-emissions for China's Imports of Cattle Meat and Soya

For the calculations below, also Equation 4 was used. Data for the calculations can be found in Table 4, Table 5, Table 7, Table 9 and Table 12.

In Table 21, China's deforestation emissions in Brazil for its imports of cattle meat can be seen and in Table 22 the ones for its imports of soya.

Table 21: CO_2-emissions through China's Import of Cattle Meat (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions from Amazon Deforestation, Min [t]	CO_2-emissions from Amazon Deforestation, Max [t]	CO_2-emissions from Cerrado Deforestation, Min [t]	CO_2-emissions from Cerrado Deforestation, Max [t]	CO_2-emissions from China's Cattle Meat Imports Total, Min [t]	CO_2-emissions from China's Cattle Meat Imports Total, Max [t]
2000	1,628,226	2,686,536				
2001	1,981,430	3,271,646				
2002	2,208,201	3,605,883	581,459	696,172	2,789,660	4,302,055
2003	3,698,630	5,787,320	723,757	866,528	4,422,387	6,653,848
2004	4,498,394	7,029,925	803,941	962,529	5,302,335	7,992,454
2005	2,514,885	4,180,696	698,322	836,075	3,213,207	5,016,771
2006	2,249,954	3,644,019	810,122	969,930	3,060,077	4,613,949
2007	2,617,384	4,239,107	1,155,558	1,383,508	3,772,943	5,622,615
2008	4,746,343	7,687,162	1,890,980	2,264,001	6,637,322	9,951,162
2009	4,200,851	6,803,685				
2010	2,679,807	4,340,206				

Table 22: CO_2-emissions through China's Import of Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions from Amazon Deforestation, Min [t]	CO_2-emissions from Amazon Deforestation, Max [t]	CO_2-emissions from Cerrado Deforestation, Min [t]	CO_2-emissions from Cerrado Deforestation, Max [t]	CO_2-emissions from China's Soya Imports Total, Min [t]	CO_2-emissions from China's Soya Imports Total, Max [t]
2000	4,888,605	8,066,086				
2001	7,166,520	11,833,028				
2002	9,903,572	16,172,046	8,897,161	10,652,439	18,800,734	26,824,485
2003	15,339,118	24,001,424	10,240,743	12,260,866	25,579,860	36,262,291
2004	17,232,027	26,929,579	10,507,083	12,579,746	27,739,110	39,509,325
2005	12,636,591	21,006,821	11,971,446	14,332,974	24,608,037	35,339,795
2006	2,803,296	4,540,209	7,124,891	8,530,371	9,928,187	13,070,580
2007	1,885,501	3,053,751	5,876,023	7,035,147	7,761,524	10,088,899
2008	2,359,022	3,820,664	6,634,253	7,942,948	8,993,275	11,763,612
2009	1,955,677	3,167,408				
2010	1,527,603	2,474,102				

China's total deforestation emissions from imports of cattle meat and soya from Brazil can be seen in Table 23. Comparing these emissions and percentages with those for the EU (see Table 19), it can be seen that until 2008, China played a minor role in deforestation in Brazil but in 2008 both countries had a share of 2 % in deforestation there, even though the EU's emissions were still higher.

Table 23: Total CO_2-emissions from Deforestation in Brazil through Chinas Import of Cattle Meat and Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to China's Imports, Min [t]	% of China's Emissions of Total Deforestation Emissions, Min	CO_2-emissions due to China's Imports, Max [t]	% of China's Emissions of Total Deforestation Emissions, Max
2002	21,590,394	2%	31,126,541	2%
2003	30,002,248	2%	42,916,139	2%
2004	33,041,445	2%	47,501,779	2%
2005	27,821,244	2%	40,356,566	2%
2006	12,988,264	1%	17,684,529	1%
2007	11,534,466	1%	15,711,513	1%
2008	15,630,597	2%	21,714,775	2%

3.1.10 CO_2-emissions for Russia's Imports of Cattle Meat

The calculations for the Russian CO_2-emissions are in general the same as for the EU and China, using the same equations and data. They have just been limited to the two years 2006, so before the FMD-outbreak in Brazil, and 2008, after the outbreak. Furthermore, just cattle meat has been looked at because Russia does not really play a role in importing soya from Brazil (see Chapter 3.1.5). See the results for Russia in Table 24 and Table 25.

Table 24: CO_2-emissions through Russia's Import of Cattle Meat (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions from Amazon Deforestation, Min [t]	CO_2-emissions from Amazon Deforestation, Max [t]	CO_2-emissions from Cerrado Deforestation, Min [t]	CO_2-emissions from Cerrado Deforestation, Max [t]
2006	26,172,436	42,388,794	9,423,692	11,282,642
2008	28,449,408	46,076,571	11,334,463	13,570,338

Table 25: Total CO_2-emissions from Deforestation in Brazil through Russia's Import of Cattle Meat and Soya (own calculations, data from FAOSTAT, 2012)

	CO_2-emissions due to Russia's Imports, Min [t]	% of Russia's Emissions of Total Deforestation Emissions, Min	CO_2-emissions due to Russia's Imports, Max [t]	% of Russia's Emissions of Total Deforestation Emissions, Max
2006	35,596,128	4%	53,671,436	4%
2008	39,783,871	5%	59,646,909	5%

From these tables it can be derived that Russia has become the main driver of deforestation emissions in 2008 after the FMD-outbreak with a share of 5 % of the total deforestation emissions in Brazil.

3.1.11 Percentages of Deforestation Caused by the Three Countries

The CO_2-emissions from deforestation caused by importing countries of Brazilian cattle meat and soya were most important for this study. However, also the direct impacts on deforestation by the EU, China and the Russian Federation have been calculated using the same equations as for the calculations above but instead of using the CO_2-emissions from deforestation, the deforestation in hectares, as stated in Table 4 and Table 5, has been used. For these calculations there are no minimum and maximum values because they were just needed due to different values for CO_2-emissions from Amazon and Cerrado deforestation. The results can be seen in Table 26.

Table 26: Results for Deforestation Due to the Imports of Cattle Meat and Soya by the EU, China and the Russian Federation

	Deforestation Due to the EU's Imports [ha]	% of EU Deforestation from Total Deforestation	Deforestation Due to China's Imports [ha]	% of China Deforestation from Total Deforestation	Deforestation Due to Russia's Imports [ha]	% of Russian Deforestation from Total Deforestation
2002	478,646	11 %	99,120	2 %		
2003	458,473	10 %	124,033	3 %		
2004	510,186	10 %	132,335	3 %		
2005	476,036	12 %	130,794	3 %		
2006	225,123	6 %	71,616	2 %	129,379	4 %
2007	159,028	5 %	63,517	2 %		
2008	99,282	3 %	80,627	2 %	148,954	4 %

It can be seen that the proportion of the EU in deforestation in Brazil with up to 12 % in 2005 is even higher than its proportion in CO_2-emissions (10 % in 2005). This is due to the fact that especially in the Cerrado, a lot of soya is grown, which causes much deforestation but emits less CO_2 per hectare than in the Amazon.

This is also true for China which is as well a large importer of soya from Brazil. For the Russian Federation, the percentage on deforestation decreased a bit in 2008 from 5 % to 4 % because it only imports cattle meat and no soya.

3.1.12 Concluding Results for Hypothesis One

These results show that imports of cattle meat play a much larger role for deforestation and CO_2-emissions that an import country causes in Brazil than soya imports. The reason is that much more deforestation occurs due to cattle ranching and that, especially in the last few years, soya has not led to much direct deforestation and resulting CO_2-emissions.

Therefore, Russia can be seen as the major foreign driver of deforestation in Brazil in the most recent year that was looked at, 2008, causing 5 % of Brazil's total CO_2-emissions from deforestation and 4 % of its deforestation. In this same year, Russia was followed by the EU and China, both responsible for about 2 % of deforestation emissions or for respectively 3 % and 2 % of deforestation in Brazil through their imports of cattle meat and soya.

In the years before, the EU has been the largest driver of deforestation in Brazil, being responsible for up to 10 % of deforestation emissions and 12 % of deforestation in the year 2005. In 2006, so the last year before the FMD-outbreak, the EU caused 6 % of CO_2-emissions and deforestation in Brazil. Russia with 4 % for both and China with 1 % of CO_2-emissions and 2 % of deforestation followed the EU in that year.

The loss of importance of the EU in causing deforestation emissions in Brazil happened with the import restrictions and bans of the EU for Brazilian cattle meat due to an FMD-outbreak in 2007 / 2008 combined with less direct deforestation for soya in Brazil. The second aspect, so the indirect deforestation of soya, will be looked at in more detail in hypothesis two. At this stage though, it should be stated, that if Brazil gets more and more FMD-free within the next years, the imports of cattle meat of the EU are likely to rise again. If they rose to the 2006 levels, the EU could again become the major driver of deforestation in Brazil but this is just speculation as also other factors like the amount of future soya imports of the EU and the amounts of future cattle meat imports of Russia influence this aspect.

Summarising, it can be said that hypothesis one "The EU causes deforestation and CO_2-emissions in Brazil to a non-negligible amount by its import of cattle meat and soya" could be confirmed because causing more than 2 % – in one year even up to 10 % – of the total deforestation emissions, and more than 3 % as well as up to 12 % of the total deforestation by importing two commodities are non-negligible in the opinion of the author. This is true even though the percentage of these emissions of the EU's total emissions was just up to 3.83 % in 2004. However, it has to be stated, that the EU has not been the major foreign driver of deforestation and related CO_2-emissions in the latest year that was looked at but that the Russian Federation was most responsible for deforestation emissions in Brazil through its imports of cattle meat and soya in 2008.

3.2 Hypothesis Two

As mentioned in Chapter 1.1.3, there is evidence of indirect land use change (iLUC) through soya expansion, mainly because plantations are often established on pastures which then move deeper into the forested regions of Brazil (e.g. Arima et al., 2011; Barona et al., 2010; Nepstad et al., 2008; Andrade de Sá et al., 2012; Ibrahim et al., 2010; HBS et al., 2013; Reichert & Reichardt, 2011; WWF UK, 2011). The use of a pasture as soya plantation is also called intensification (Macedo et al., 2012).

One indicator for this fact is that the cattle density in the Amazon grew much more than the cattle density in the Cerrado, which led to a situation where the cattle density is now higher in the Amazon than in the Cerrado (see Figure 38; IBGE, 2007; Andrade de Sá et al., 2012).

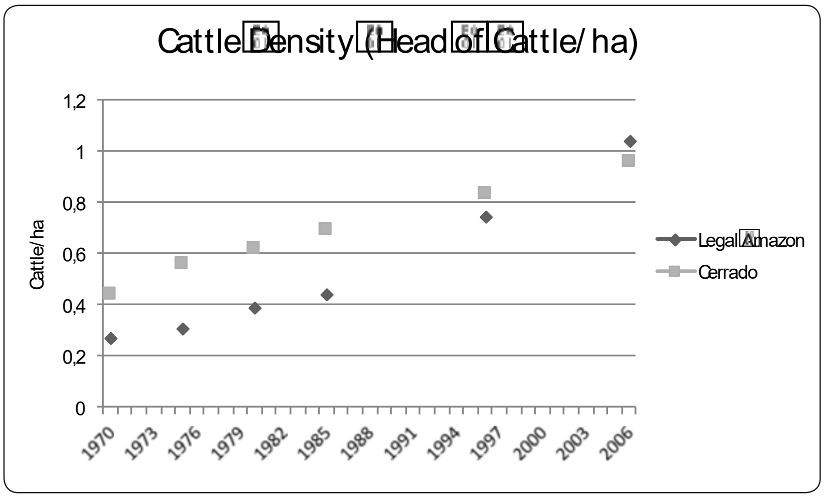


Figure 38: Development of the Cattle Density in the Legal Amazon and the Cerrado since 1970 (own figure, data from IBGE, 2007)

Ibrahim et al. (2010) also give more figures for cattle expansion in the Amazon: „Whereas the Legal Amazon's total herd grew 110 % in the 1996 – 2005 period, the growth in other regions of Brazil was only 14 %" (p. 76).

The indications for iLUC lead to the assumption that the emissions given for deforestation due to soya in the results for hypothesis one are too low because the soya plantations that occupy cattle pastures are, at least partly, responsible for deforestation caused by the establishment of new pastures deeper in the forest.

In the following subchapters an own approach for calculating the emissions that should be added to soya has been developed. This is because, as stated in Chapter 1.1.3, taking an iLUC factor appears to be too imprecise with the current status of research. Hence, at the end of this subchapter, the deforestation emissions from cattle meat and soya imports of the considered countries are stated anew in a more realistic way.

3.2.1 Own Approach for Calculating Additional Emissions from Soya

The idea is to find out how large the area of soya, which was established on cattle pastures was and how long the pasture had been there before the soya occupation.

According to IPCC rules (IPCC, 2006), the emissions from deforestation are distributed over 20 years. So, if soya occupies a pasture which has been on a deforested place for X years, the emissions should be partially redistributed and added to soya according to Equation 5:

Equation 5: Partial Redistribution of the Emissions from Pasture to Soya According to the Length of Pasture Occupation of a Deforestaed Area

$$additional\ emissions\ for\ soya = deforestation\ emissions\ for\ cattle\ pasture \times \frac{(20-X)}{20}$$

At the same time, the emissions for cattle meat should be reduced by this amount. Thus, in this approach, no additional emissions for iLUC are calculated but the actual emissions for soya and cattle meat are redistributed taking the “displacement effect” into account.

This own approach has not been tried by other researchers, as far as known, and is based in part on life cycle assessment where all emissions are distributed among the produced goods.

3.2.2 How Large is the Area of Pasture Occupied by Soya and how much CO_2 was Released during its Deforestation?

At first, the expansion of soya area in Brazil within the last decade has been calculated as two 5-year averages, from 2001 until 2005 and from 2006 until 2010. In Table 27, the results can be seen.

Table 27: Calculation of Expansion of Soya Plantations for 2001 – 2005 and 2006 – 2010 (own calculatins, data from FAOSTAT, 2012)

	Area Planted with Soya Beans [ha]	Expansion of Soya Area [ha]	Average Expansion for 5-Year Periods [ha / year]
2000	13,640,000		
2001	13,974,300	334,300	2001 – 2005 1,861,780
2002	16,365,400	2,391,100	
2003	18,524,800	2,159,400	
2004	21,539,000	3,014,200	
2005	22,948,900	1,409,900	
2006	22,047,300	-901,600	2006 – 2010 75,680
2007	20,565,300	-1,482,000	
2008	21,246,300	681,000	
2009	21,750,500	504,200	
2010	23,327,300	1,576,800	

In Figure 32, it could already be seen that the soya expansion happened mainly in the first half of the last decade whereas in the second half, the area even decreased in some years. That is why the two 5-year averages differ considerably from each other. From these figures it can already be said that the area of pastures occupied by soya was much larger in between 2001 – 2005 than between 2006 – 2010.

A reason why 5-year averages have been calculated is that in Macedo et al. (2012) percentages for soya plantations occupying pasture have been found also for these periods. They did an investigation for the state of Mato Grosso and found that between 2001 and 2005 on average 74 % of soya expansion took place on areas that had been cleared for pasture before. Between 2006 and 2010, this has been the case in 91 % of soya expansion (Macedo et al., 2012). The study by Macedo et al. (2012) gives evidence that it is a pattern that soya is planted on pastures or as formulated in hypothesis two, it is planted there systematically.

Using these numbers, the area of pasture occupied by soya can be calculated as demonstrated below in Equation 6 and Equation 7.

Equation 6: Calculation of Pasture Area that was Occupied by Soya Between 2001 – 2005 (own calculation, data from FAOSTAT, 2012; Macedo et al., 2012)

$$pasture\ area\ occupied\ by\ soya\ between\ 2001 - 2005 = 1{,}861{,}780 ha/year \times 74\% = 1{,}377{,}717 ha/year$$

Equation 7: Calculation of Pasture Area that was Occupied by Soya Between 2006 – 2010 (own calculation, data from FAOSTAT, 2012; Macedo et al., 2012)

$$pasture\ area\ occupied\ by\ soya\ between\ 2006 - 2010 = 75{,}680 ha/year \times 91\% = 68{,}869 ha/year$$

With these figures, the minimum and maximum CO_2-emissions that have been emitted during deforestation for these sizes of pasture can be calculated. As approximately 50 % of Mato Grosso, where the data for percentage of occupation is from, is Cerrado and approximately 50 % is Amazon (see e.g. Macedo et al., 2012), the means of the figures for CO_2-emissions / ha for the Cerrado and the Amazon have been taken: for the minimum value, the mean of 455t CO_2 / ha and 131t CO_2 / ha is 293t CO_2 / ha and for the maximum value, the mean of 737t CO_2 / ha and 157t CO_2 / ha is 447 t CO_2 / ha. The area of deforestation as seen above has been multiplied with these values, see Table 28.

Table 28: Overview of Area of Pasture Occupied by Soya and the CO_2-emissions that have been emitted during Deforestation of this Area, Minimum and Maximum (own calculations, data from FAOSTAT, 2012; MCT Brazil, 2010; Fargione et al., 2008)

	Area of Pasture Occupied by Soya [ha / year]	CO_2-emissions from Deforestation for this Area of Pasture, Min. [t / year]	CO_2-emissions from Deforestation for this Area of Pasture, Max. [t / year]
2001 – 2005	1,377,717	403,795,134	615,839,588
2006 – 2010	68,869	20,184,757	30,784,354

3.2.3 Redistribution of these Emissions to Cattle Meat and Soya Production

In Macedo et al. (2012) it is also stated how old pastures are on average when they get occupied by soya, see Figure 39. This finding is another indicator that soya is systematically planted on pasture at a certain point in time.

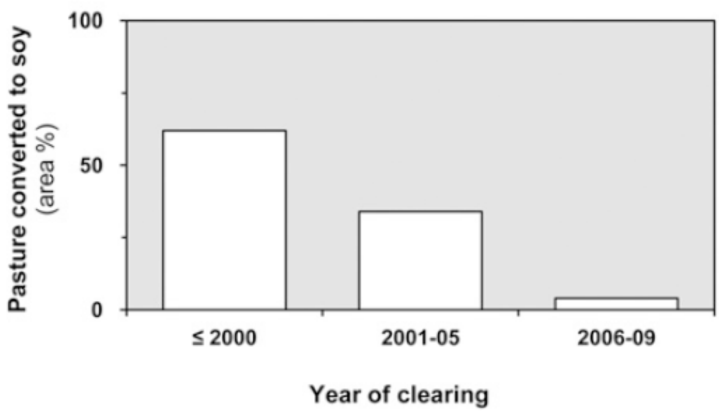


Figure 39: Age Distribution of the Pastures that have been Converted to Soya between 2005 and 2009 in the State of Mato Grosso (Macedo et al., 2012, Figure 4B, p. 1343, © PNAS)

It is difficult to derive exact numbers of the age of the pasture during conversion to soya from this figure. Thus for all given years, the upper ones have been used. See Chapter 4.1.3 in the Discussion for more details about this uncertainty.

As a result it could be derived that 62 % of the occupied pastures were 10 years or older, 34 % were 5 years old and 4 % were 1 year old. The average age of pastures during occupation of soya was calculated in Equation 8:

Equation 8: Calculation of the Average Age of Pastures during Occupation of Soya (own calculation, data from Macedo *et al*., 2012)

$$average\ age\ of\ pasture\ during\ occupation\ by\ soya = 62\% \times 10 + 34\% \times 5 + 4\% \times 1 = 8\ years$$

An average occupation of eight years for pastures matches with the statement of Alves et al. (2009) that after five to seven years the productivity of the pasture decreases significantly, even though this is also dependent from factors such as climate, soil and the management of the pasture.

According to the method described in Chapter 3.2.1, this means that there is pasture on the deforested area for 8 out of 20 years or approximately 40 % of the time. Hence, soya is occupying the area for 60 % of the time. It is assumed that soya will be planted on the area for this period of time because Alves et al. (2009) state that often plantations are “used until soil nutrients are depleted” (p. 18).

With this knowledge, the additional deforestation emissions for soya, which are as well the emissions that should be deducted from cattle meat can be calculated using Equation 5 (see above).

Data is available for the expansion of soya on pastures for just the two periods 2001 – 2005 and 2006 – 2010 and not annually. Thus, the emissions that need to be added to soya / deducted from cattle can just be given for these two time periods and not for each year.

The results are shown in Table 29 (minimum) and Table 30 (maximum). These tables show as well a comparison of the old and new CO_2-emissions for cattle meat and soya in Brazil.

Table 29: Minimum CO_2-emissions that Need to be Added to Soya / Deducted from Cattle Meat and Comparison of Old and New CO_2-emissions for Cattle Meat and Soya, Minimum (own calculations)

	CO_2-emissions to Add to Soya / to Deduct from Cattle Meat [t]	CO_2-emissions for Cattle Meat in Brazil, Old [t]	CO_2-emissions for Cattle Meat in Brazil, New [t]	CO_2-emissions for Soya in Brazil, Old [t]	CO_2-emissions for Soya in Brazil, New [t]
2001	242,277,080				
2002	242,277,080	987,586,200	745,309,120	185,504,850	427,781,930
2003	242,277,080	1,144,200,240	901,923,160	199,477,520	441,754,600
2004	242,277,080	1,235,040,240	992,763,160	210,832,520	453,109,600
2005	242,277,080	861,630,640	619,353,560	164,156,320	406,433,400
2006	12,110,854	707,326,317	695,215,463	46,047,092	58,157,946
2007	12,110,854	611,401,457	599,290,603	43,648,970	55,759,824
2008	12,110,854	657,270,650	645,159,796	44,795,700	56,906,554
2009	12,110,854				
2010	12,110,854				

Table 30: Maximum CO_2-emissions that Need to be Added to Soya / Deducted from Cattle Meat and Comparison of Old and New CO_2-emissions for Cattle Meat and Soya, Maximum (own calculations)

	CO_2-emissions to Add to Soya / to Deduct from Cattle Meat [t]	CO_2-emissions for Cattle Meat in Brazil, Old [t]	CO_2-emissions for Cattle Meat in Brazil, New [t]	CO_2-emissions for Soya in Brazil, Old [t]	CO_2-emissions for Soya in Brazil, New [t]
2001	369,503,753				
2002	369,503,753	1,522,999,556	1,153,495,803	264,674,359	634,178,112
2003	369,503,753	1,721,544,160	1,352,040,407	282,781,520	652,285,273
2004	369,503,753	1,861,633,120	1,492,129,367	300,292,640	669,796,393
2005	369,503,753	1,345,261,440	975,757,687	235,746,180	605,249,933
2006	18,470,612	1,066,498,560	1,048,027,948	60,621,564	79,092,176
2007	18,470,612	911,138,960	892,668,348	56,737,574	75,208,186
2008	18,470,612	985,428,560	966,957,948	58,594,814	77,065,426
2009	18,470,612				
2010	18,470,612				

3.2.4 New Calculation of the EU's Deforestation Emissions in Brazil due to its Imports of Cattle Meat and Soya

Using the EU's import percentages of Brazilian cattle meat (see Table 9) and soya (see Table 12), the new CO_2-emissions the EU has caused in Brazil in the last decade can be calculated. These emissions are shown below in Table 31 (minimum values) and Table 32 (maximum values).

Table 31: New CO_2-emissions for the EU's Imports of Cattle Meat and Soya, Absolute and Relative to Brazil's Total Deforestation Emissions, Minimum (own calculations)

	CO_2-emissions for the EU's Cattle Meat Imports, New [t]	% of total CO_2-emissions from Deforestation for the EU's Cattle Meat Imports, New	CO_2-emissions for the EU's Soya Imports, New [t]	% of total CO_2-emissions from Deforestation for the EU's Soya Imports, New
2002	19,082,765	1.49 %	190,288,193	14.87 %
2003	29,065,236	1.98 %	177,622,422	12.07 %
2004	40,758,968	2.57 %	184,132,637	11.62 %
2005	30,308,410	2.71 %	168,708,434	15.09 %
2006	34,572,380	3.74 %	20,163,680	2.18 %
2007	17,991,786	2.23 %	17,858,890	2.22 %
2008	3,906,113	0.45 %	17,284,233	2.00 %

Table 32: New CO_2-emissions for the EU's Imports of Cattle Meat and Soya, Absolute and Relative to Brazil's Total Deforestation Emissions, Maximum (own calculations)

	CO_2-emissions for the EU's Cattle Meat Imports, New [t]	% of total CO_2-emissions from Deforestation for the EU's Cattle Meat Imports, New	CO_2-emissions for the EU's Soya Imports, New [t]	% of total CO_2-emissions from Deforestation for the EU's Soya Imports, New
2002	29,533,906	1.51 %	282,098,421	14.41 %
2003	43,570,644	1.98 %	262,273,421	11.91 %
2004	61,260,989	2.58 %	272,188,839	11.45 %
2005	47,749,244	2.76 %	251,236,164	14.51 %
2006	52,117,397	3.77 %	27,421,693	1.98 %
2007	26,799,516	2.26 %	24,087,857	2.03 %
2008	5,854,437	0.46 %	23,407,089	1.83 %

Furthermore, the total deforestation emissions the EU caused in Brazil have been calculated as well as the relative impact of the EU on deforestation emissions in Brazil, see Table 33 (minimum) and Table 34 (maximum). In these tables it can be seen how the increase was from the previous, initial calculation method to the new, own calculation method.

Table 33: Total CO_2-emissions for the EU's Imports, Absolute and Relative, and Increase Compared to the Old Calculation, Minimum (own calculations)

	CO_2-emissions for the EU's Imports, New [t]	% of Total CO_2-emissions from Deforestation, New	Increase in CO_2-emissions from Old to New Calculation [t]	Increase in CO_2-emissions from Old to New Calculation
2002	209,370,958	16%	101,567,736	94%
2003	206,687,658	14%	89,608,135	77%
2004	224,891,605	14%	88,508,520	65%
2005	199,016,844	18%	88,712,019	80%
2006	54,736,061	6%	3,596,639	7%
2007	35,850,676	4%	3,515,303	11%
2008	21,190,346	2%	3,605,106	21%

Table 34: Total CO_2-emissions for the EU's Imports, Absolute and Relative, and Increase Compared to the Old Calculation, Maximum (own calculations)

	CO_2-emissions for the EU's Imports, New [t]	% of Total CO_2-emissions from Deforestation, New	Increase in CO_2-emissions from Old to New Calculation [t]	Increase in CO_2-emissions from Old to New Calculation
2002	311,632,327	16%	154,903,880	99%
2003	305,844,065	14%	136,663,948	81%
2004	333,449,828	14%	134,986,892	68%
2005	298,985,408	17%	135,297,255	83%
2006	79,539,091	6%	5,485,338	7%
2007	50,887,373	4%	5,361,291	12%
2008	29,261,526	2%	5,498,251	23%

Comparing the results in the two tables above to Table 19 with the results for hypothesis one for the EU, it can be seen that the impact of the EU is considerably larger than thought by conventional calculation methods: In 2005, the EU drove 18% of deforestation emissions in Brazil rather than 10% as calculated with the old method. The increase in deforestation emissions caused by the EU can be seen in the third and fourth column of the two tables above: for example in 2002, the CO_2-emissions are 99% higher with the new calculation method.

Particularly in the years with large quantities of imported cattle meat and soya, the impact of the EU on deforestation in Brazil increased dramatically when compared to the calculations that were not considering soya occupying pastures. This is due to the fact that the EU is importing much more soya than cattle meat, so the additional emissions for soya plantations coming with the new calculation method have a large impact on the EU's deforestation emissions in Brazil.

That soya has a much stronger influence on the EU's deforestation emissions in Brazil using the new calculation method can also be seen by comparing Figure 40 below with Figure 36. Both show the proportions of emissions due to cattle meat and soya in the EU's emissions.

As the contribution of the EU in emissions in Brazil increased with this new calculation method, also the percentage in the EU's total emissions and in its agricultural emissions increased. As can be derived from Table 35 the additional emissions make up nearly 0.6% of the EU's total emissions and more than 4% of its agricultural emissions in 2008 and even up to 6.44% of the EU's total emissions in 2004.

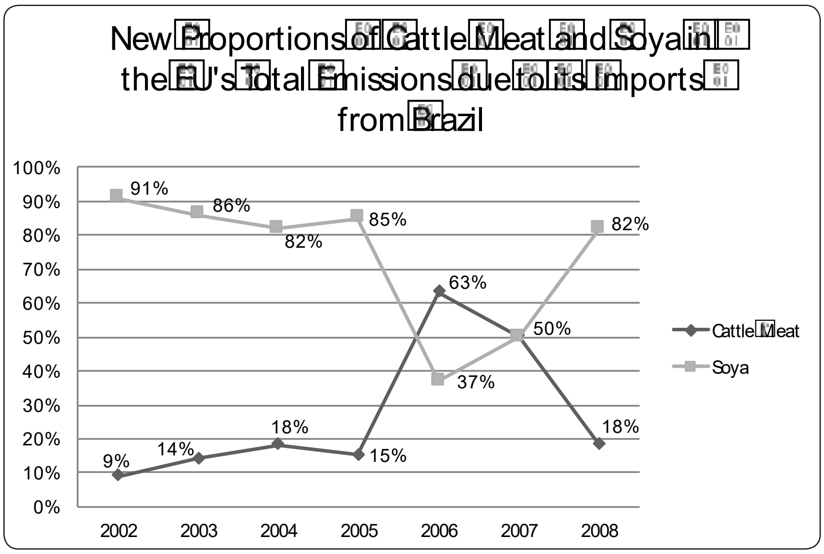


Figure 40: New Proportions of Cattle Meat and Soya in the EU's Total Emissions due to its Imports from Brazil (own figure)

Table 35: Percentages of the Additional CO_2-emissions of the EU Caused in Brazil of its Total Domestic and Agricultural Emissions for 2004 and 2008, New Calculation (data from Eurostat, 2012 and 2013 as well as FAOSTAT, 2012)

	Total Emissions of the EU [CO_2-equivalent]	% of the Additional Emissions	EU Emissions from Agriculture, Hunting, Forestry & Fishing [CO_2-equivalent]	% of the Additional Emissions
Min. 2004	5,177,932,000	4.34 %		
Max. 2004		6.44 %		
Min. 2008	4,974,387,000	0.43 %	676,516,632	3.13 %
Max. 2008		0.59 %		4.33 %

3.2.5 Comparison of the EU's Deforestation Emissions in Brazil with those of China and the Russian Federation

The deforestation emissions of China and Russia have also been recalculated using the new method; the results can be seen in Table 36 (China) and Table 37 (Russia).

Table 36: China's New Deforestation Emissions in Brazil, Absolute and Relative, Minimum and Maximum (own calculations)

	CO_2-emissions for the Imports of China New, Min. [t]	% of total CO_2-emissions New, Min.	CO_2-emissions for the Imports of China New, Max. [t]	% of total CO_2-emissions New, Max.
2002	45,460,571	4 %	67,531,636	3 %
2003	60,134,068	4 %	88,871,045	4 %
2004	63,877,541	4 %	94,530,797	4 %
2005	63,236,557	6 %	94,369,481	5 %
2006	15,547,083	2 %	21,587,059	2 %
2007	13,613,245	2 %	18,881,918	2 %
2008	17,939,697	2 %	25,236,450	2 %

Table 37: Russia's New Deforestation Emissions in Brazil, Absolute and Relative, Minimum and Maximum (own calculations)

	CO2-emissions for the Imports of Russia New, Min. [t]	% of total CO2-emissions New, Min.	CO2-emissions for the Imports of Russia New, Max. [t]	% of total CO2-emissions New, Max.
2006	34,986,650	4%	52,741,904	4%
2008	39,050,814	5%	58,528,903	5%

For China, the proportion in Brazil's deforestation emissions rose in a similar proportion to the EU because China is a large soya importer. Thus, the new calculation method means additional emissions for China as well. For Russia, nothing really changed in 2006 and 2008 because in these years, the redistribution of emissions from cattle meat to soya was very low due to the fact that there was rarely an expansion in soya plantations from 2006 until 2010.

The EU had been the major driver of deforestation in Brazil in 2006 being responsible for 6% of total deforestation emissions there whereas China and Russia were responsible for 2% and 4% respectively and did not change with the application of the new calculation method. Also the fact, that in 2008, Russia was the major deforestation driver in Brazil, being responsible for 5% of total deforestation emissions whereas the EU and China both caused only a 2% change each did not change by calculating with more appropriate numbers for emissions due to soya and cattle meat.

3.2.6 Percentages of Deforestation Caused by the Three Countries

The direct deforestation of all three countries has been recalculated as well, see Table 38.

It can be seen that the proportion of the EU in deforestation in Brazil was up to 19% in 2005 and is higher than its proportion in CO_2-emissions in 2005 (18%). This has also been the case for the calculations for hypothesis one. For China, some percentages in deforestation are higher than its percentages in CO_2-emissions in Brazil – for Russia the 2008 value is a bit lower. As described above, this can be explained through the effects of soya which accounts for more deforestation than CO_2-emissions because the emissions are low in the Cerrado where a lot of soya is grown.

Table 38: Results for Deforestation Due to the Imports of Cattle Meat and Soya by the EU, China and the Russian Federation, New Calculation Method

	Deforestation for the Imports of the EU, New [ha]	% of the EU in Total Deforestation, New	Deforestation for the Imports of China, New [ha]	% of China in Total Deforestation, New	Deforestation for the Imports of Russia, New [ha]	% of Russia in Total Deforestation, New
2002	825,187	18%	180,563	4%		
2003	764,209	16%	226,840	5%		
2004	812,170	17%	237,545	5%		
2005	778,714	19%	251,628	6%		
2006	237,395	7%	80,347	2%	127,300	4%
2007	171,022	5%	70,610	2%		
2008	111,583	3%	88,505	3%	146,453	4%

3.2.7 Concluding Results for Hypothesis Two

Using the new calculation method shows the real extent of the impact of the EU on deforestation in Brazil. Especially in the years with much soya expansion, the differences in calculation between the conventional and the new method were dramatic. It can be shown that the EU caused up to 18% of deforestation emissions in Brazil. These emissions even reach up to 19% of deforestation in the year 2005. In 2004, the EU's deforestation emissions in Brazil made up more than 6% of its domestic emissions. This fact underlines and confirms again hypothesis one that the EU has, at least in the early to mid 2000s, been a major driver of deforestation in Brazil. Until 2006 it has even been the largest driver, as already mentioned in the conclusion for hypothesis one.

The fact that Russia was the major foreign driver of deforestation and emissions in Brazil in 2008 with 5% of all deforestation emissions and 4% of all deforestation did not change much when indirect land use change was considered. This can be explained by the fact that soya expansion was so low from 2006 on that indirect land use change did not account for much deforestation and emissions.

So in this subchapter 3.2 it could be confirmed that the deforestation emissions of soya are too low in the calculations for hypothesis one. This is because soya is systematically planted on pasture land which has only been converted some few years before, as assumed in hypothesis two; and it could even be quantified.

This data shows that conventional studies have left out considerable amounts of CO_2-emissions and deforestation related to the soya imports of nations. At the same time, the study at hand exemplifies a method of how these emissions and this deforestation caused by indirect land use change can be included in future studies.

4 Discussion

In this chapter the uncertainties, the data quality, the limitations, the scope of the study, and the approach for quantifying indirect land use change are discussed. When using the results of this study, it is important to always keep the issues mentioned in this chapter in mind.

4.1 Uncertainties and Data Quality

At first, uncertainty and data quality is a main issue in this study because the results fully depend on the figures found in literature which are used for the calculations.

Partly, only few figures and studies have been found and some aspects have just been stated in grey literature or on the internet, so without peer review. It has to be known that research on the issues investigated here is in its early stages and is not abundant – especially not in the English language. For all the figures used the sources are given so that the reader can decide if he or she trusts this information. The author of this study believes that all cited sources and figures are reliable. As often as possible official governmental data has been used. The author of this study does not see a problem in using figures from the reports of NGOs (such as Greenpeace). This is because they know the region and mainly base their findings on satellite data, surveys, own field data or governmental figures. Most of the time there were different figures available the more conservative values have been taken in order to not overestimate any effect.

The figures that were used are only valid for the mentioned and calculated years. For more recent years research on current figures is required. This is especially necessary for the proportions of cattle pastures and soya plantations causing Amazon and Cerrado deforestation as well as for the average point in time when soya is expanding on pastures.

In the following more specific uncertainties with data quality are discussed.

4.1.1 Values for Cerrado CO_2-emissions per Hectare

The CO_2-emission values taken for the Cerrado must be viewed with caution. There are quite different numbers in the literature of how much carbon is really stored in this quite diverse ecosystem and released following deforestation. The minimum value of 131.13 t CO_2/ha is derived from official Cerrado deforestation and related CO_2-emissions data (Brazilian Government, 2009 and MCT Brazil, 2010). The maximum value of 157t CO_2/ha that was taken for the calculations, was derived from Fargione et al. (2008). This is also from whom the maximum value of Amazon CO_2-emissions that was taken for this study comes from. The value was then converted to the needed value using government data on the percentages of vegetation types in the Cerrado (FAO, 2010). However, this maximum value could still underestimate the CO_2-emissions from the Cerrado. Fritsche (2010) gives 491t CO_2/ha for the conversion of savannah to sugar cane. Moreover, as stated in Lal (2008) and PPCerrado, the “Plan for Prevention and Control of Deforestation and Forest Fires in Cerrado” (Brazilian Federal Government, 2010), the IPCC (2000) gives a carbon value for the Cerrado of 146t C/ha and Abdala (1993) gives a value of 265t C/ha. The CO_2-emissions, if all of that carbon would be emitted, would be 535t CO_2/ha or 972t CO_2/ha respectively. However, it is stated in neither of these two literature sources how much CO_2 will be really emitted during land use change to a pasture or soya plantation as the land will not be carbon or CO_2-free. Another uncertainty are the different calculation methods: was above- and belowground biomass counted and were other GHGs like N2O and CH4 counted? This is not clear in some of these studies. The maximum CO_2-emission values of the Cerrado taken here from Fargione et al. (2008) seem trustworthy because they clearly state that this figure is the CO_2-emissions from soil and above- and belowground biomass of converted Brazilian Cerrado to cropland. Like this, the consistency between Amazon and Cerrado CO_2-emissions can be guaranteed as the maximum values are derived from the same literature source.

Another aspect that should be added here is that the discussion about the most appropriate figures for the CO_2-emissions per hectare is necessary to quantify the absolute emissions from deforestation, but as the calculations with minimum and maximum values showed, for the relative importance of e.g. the EU in causing deforestation emissions in Brazil, the value for the CO_2-emissions per hectare does only play a very minor role. Hence, these relative values in the results of this study are valid for any amount of Amazon or Cerrado per hectare emissions value.

4.1.2 Area of Soya

The official numbers from the Brazilian government for "soya area harvested" which were taken to calculate the additional impact of soya which occupies pasture after some years in hypothesis two is very low and in some years even decreasing. Macedo et al. (2012) compare these numbers from IBGE with ones they derived from the MODIS system for the state of Mato Grosso (see Figure 41).

It can be seen that the soya area might not have decreased so heavily or not at all from 2006 on as the official numbers (dotted lines) suggest. The correctness of the numbers cannot be verified easily, which is why the more conservative official data has been used. Yet, if the number of soya area increase was higher than official data says, the CO_2-emissions of soya are also higher and are thus underestimated in this study. At the same time, the CO_2-emissions from cattle meat would then be lower and thus overestimated in this study.

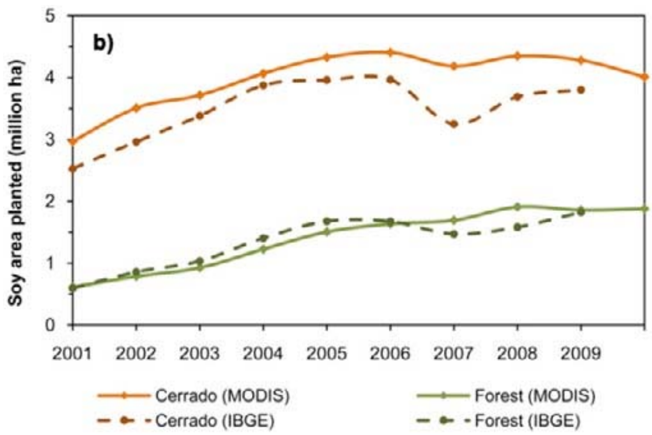


Figure 41: Planted Area of Soya Beans in the Cerrado and the Amazon with official IBGE Data as well as MODIS Data (Macedo et al., 2012, Supporting Information, p. 5, © PNAS)

4.1.3 Length of Pasture Occupation Before Soya

This discussion is related to Chapter 3.2.3, especially to Figure 39.

At first, it has to be recognised that for the length of pasture occupation after deforestation and the point in time when there is a conversion to soya, just one literature source was found. The authors Macedo et al. come from the US and Brazil and the paper was published in the scientific journal PNAS in 2012. Even though the paper and the figures seem trustworthy, having just one reference is a cause for uncertainty because if they used inaccurate values in this paper, this translates to errors made in the calculations in this study. This is an uncertainty for other figures used here as well.

The aspect that needs to be discussed is the numbers that were derived from Figure 39. Macedo et al. (2012) state that it can be seen in this figure how old the pastures were that have been converted to soya between 2005 and 2009. It can be seen immediately, that pastures converted in 2005 cannot fall into the third category with a clearing year between 2006 and 2009. Furthermore, it is not stated how old the maximum age of pastures is in the first category. It is also unclear in which month the clearing and the conversion happened. If the clearing happened in early 2009 and the conversion in late 2009, the pasture would also be nearly one year old. In Table 39 you can see all values for conversion ages that can theoretically be derived from Figure 39.

Table 39: Uncertainties with the Values Derived from Figure 39 (Macedo et al., 2012): Overview of Possible Values and Used Values

Clearing in Year…	Possible Age of Pasture During Conversion	Age Taken for Calculation
2000 or before	5 to more than 9 years	10 years
2001 – 2005	0 – 8 years	5 years
2006 – 2009	0 – 3 years	1 year

It can be seen in this overview that the values used in this study are more or less average values of what is possible. As stated in Chapter 3.2.3, the used values were derived from always taking the most recent year given. Additionally, it has been estimated that there was at least one year between deforestation and conversion e.g. through deforestation at the beginning and conversion at the end of the year.

It is hoped that under- and overestimation of the real age of the pastures more or less equalise each other so that the used average of eight years is realistic. However, with the available data no better estimation or calculation was possible.

4.1.4 Other Uncertainties

A very important uncertainty comes with certified soya and cattle meat. If the EU imported much of these special products, so deforestation-free ones, the results derived here are overestimating the EU's impact on deforestation in Brazil. As there is no data on the exports and imports of certified products this uncertainty could not be resolved. However, the results generated are for the years between 2002 and 2008 but soya certification only started in 2006 and cattle meat certification in 2009. So, if there was an effect from certified soya reducing the EU's impact, it would only concern the last few years in the calculations but not the ones for the first years. These effects would probably be negligible.

Another aspect is that the calculated CO_2-emissions from deforestation in Brazil for export goods of the EU are allocated to the EU in this study. However, the EU itself is as well exporting the commodity "animal feed" (see European Commission, 2012), so it might be possible that some emissions need to be reallocated to these importing countries of soya from the EU. From the database of the European Commission (2012) it can be derived that Algeria is an importing country of animal feed from the EU and that the quantities are much lower than the ones the EU imports from Brazil. Furthermore, this animal feed is most likely not soya but other feed grown in the EU. However, this cannot be examined in detail because there is no data which means that it is possible that the impact of the EU is slightly overestimated.

These uncertainties above are the main ones. Others are also stated in the respective parts of the results.

4.2 Limitations / Scope of the Study

In Chapter 1.2.5 the scope of the study has already been described but the main aspects shall be repeated here because knowing about the limitations of the generated results is important when they are communicated.

It has to be clear that no full life cycle assessment has been done and that not all emissions related to cattle meat and soya were considered. Only those emissions that are directly emitted from Amazon and Cerrado deforestation with the described CO_2-emission values are part of this calculation. Not considered are emissions other than CO_2, emissions from transportation, deforestation for infrastructure, processing, export and so on. If all of this would be taken into account as well the emissions would probably be twice as high as has been shown by Reichert & Reichardt (2011) for soya imports to Germany.

4.3 Approach for Quantifying Indirect Land Use Change

The calculation of the iLUC of soya made in this study is an approach of how this effect could be quantified best with the available data. As far as the author of this study knows, nobody else has done this or a similar calculation before, thus the risk of errors is a strong possibility.

The calculation is dependent on accurate data for the single years. As shown above, especially the area of soya expansion and the point in time when pastures get occupied are very important. If the area of plantations decreases in a year and increases again, it is unclear what happened to this area in between. If there was no activity, there will also be no iLUC or deforestation for soya plantations occupying exactly this area again. This very conservative assumption has been made for the calculations in this study because by taking 5-year averages for soya expansion the derived value is rather low.

Moreover, it has to be known that the emissions attributed to soya additionally due to iLUC are already allocated to it and the importing country before it has been planted, so in the year when there is deforestation for a cattle pasture. An allocation in exactly the eighth year when on average soya is planted on the pastures was not realisable in this study, unfortunately. This is a very complex problem and should be investigated further by other studies. Thus, this means that for soya importing countries where the soya imports from Brazil are decreasing, the emissions might be overestimated.

So, before taking this approach for further calculations it should be checked if there are new developments concerning for example the iLUC factor or other methods. If this is the case, then the approach given here should be compared and possibly adjusted.

Concluding, it can be said that efforts have been made to get the most appropriate and reliable figures for all calculations and that rather conservative figures have been taken in case of uncertainty. Thus, the effects of the EU's imports of cattle meat and soya have likely been underestimated rather than overestimated except for some steps in the calculation where this was unavoidable.

5 Conclusions, Recommendations and Outlook

In this last chapter, all results are recapitulated and final conclusions from this study are drawn. Then, recommendations are given on how deforestation in Brazil could be decreased, especially by lowering the EU's impact on deforestation there. Lastly, an outlook is given on how future studies could deal with the topic.

5.1 Conclusions from the Results

At first, the development of deforestation in the Amazon and the Cerrado could be shown. In the Amazon, there was a peak of deforestation in 2004 with a deforested area of more than 27,000 km², since then it has been decreasing. In 2012, the deforestation was about 5,000 km², so much lower than e.g. in 2004 but still at a high level. The decrease in deforestation is a reason of forest protection laws which therefore can be considered as being successful in lowering deforestation but until now not successful in really stopping it. Whereas deforestation in the Amazon gained international attention, deforestation in the Cerrado savannah, which is also very rich in biodiversity, remained mostly unattended by the general public of the EU. The official figures on Cerrado deforestation, which are available for the years 2002 until 2008, show, however, that deforestation there is even more worrying: since 2005, the area of deforestation was higher than that in the Amazon with 21,000 km² annually. Furthermore, already up to 80 % of the original vegetation has been lost. This leads to the conclusion that international attention also needs to focus on this biome and that special laws and instruments to stop Cerrado deforestation need to be developed or rather applied more effectively.

Moreover, it could be shown that cattle pastures are the main direct drivers of deforestation in the Amazon and the Cerrado with 80 % and 68 % respectively. The direct impact of soya has decreased from 10 % in the Amazon and 29 % in the Cerrado to 2 % and 12 % respectively in the second half of the last decade. This decrease can be attributed to the soya moratorium, a voluntary agreement of soya traders not to buy and sell soya from deforested areas, which was signed by a lot of these companies in 2006. There is also a beef moratorium in Brazil since 2009. In the used literature, no statement about its effects has been found but this moratorium has probably also led to a reduced impact of cattle on deforestation in Brazil or could do so in the future. Programmes and voluntary agreements like this seem to be urgently needed looking at the large impact of cattle pastures on deforestation.

The study at hand was dealing as well with the underlying drivers of deforestation in Brazil and found out that production increases in cattle meat and soya, going mostly together with pasture and plantation expansion, were driven by foreign demand and imports of these commodities. This confirmed the theory of land displacement by Meyfroidt et al. (2010) saying that deforestation in a country correlates with its amount of agricultural exports and that a low rate of deforestation correlates with the amount of agricultural imports.

Especially the land displacement hence deforestation for the EU in Brazil has been looked at and found out to be non-negligible: in 2008, the EU was the second largest foreign driver of deforestation in Brazil and until 2006, it was even the largest. In 2005, the year when the EU's impact on deforestation in Brazil was highest, it was responsible for 19 % of all deforestation and 18 % of all deforestation emissions there. In 2004, these emissions of the EU in Brazil were as high as 6.44 % of the EU's total CO_2-emissions. In 2008, the EU's impact was reduced to 3 % of deforestation and 2 % of deforestation emissions due to lower imports of cattle meat and soya from Brazil, among other reasons due to an FMD-outbreak in Brazil and more rapeseed production in the EU for biodiesel of which the leftovers can be used as animal feed. The development of the EU's imports of soya are likely to continue decreasing in the future but the imports of cattle meat might increase again when Brazil becomes FMD-free in the next years. Then, the EU's impact on deforestation in Brazil will most likely rise again.

Also Russia, the major cattle meat importer, and China, since a few years the major soya importer, were looked at. Russia turned out to be the major foreign driver of deforestation in 2008, being responsible for 4% of deforestation and 5% of deforestation emissions in Brazil. China was on rank three and caused 3% of deforestation as well as 2% of deforestation emissions in 2008. This is surprising because often China with its growing consumption and demand is blamed for its climate-damaging impacts worldwide but Russia is only seldom in the centre of the discussion. The study at hand shows therefore, that the focus on countries exerting demand-side pressure on forests should be broadened and that the responsibility of Russia should be more emphasised in the climate negotiations. The import quantities of cattle meat and soya of other countries which also have a share in deforestation in Brazil are listed in the appendix but Russia, the EU and China are the three major ones.

Since production and export of cattle meat and soya are predicted to rise also in the future, the pressure on Brazilian forests is expected to remain high.

Another aspect that could be shown with this study is that soya is planted on pastures systematically, on average after eight years. An own method has been developed to quantify the indirect land use change of soya due to this pattern as by using existing methods, the results are very unspecific. This new method allocates the deforestation emissions in accordance to the occupation time of cattle and soya for the share of soya spreading on existing pastures. The results show that the effects of iLUC are quite high with emissions from soya nearly doubling in years with much soya expansion. Hence, previous studies dealing with the impacts of cattle meat and soya on deforestation in Brazil have largely underestimated the effect of soya and it is a more serious threat to deforestation than the figures on the percentages of Amazon and Cerrado deforestation suspect. The positive effect of the soya moratorium has to be questioned consequently. New studies relating deforestation to imports of goods should integrate the iLUC effect, for example by using the new method described in this study.

To sum it up, the study at hand has successfully confirmed both hypothesis and quantified the deforestation and deforestation emissions in Brazil the EU is causing. It has thus shown how large the responsibility of the EU in Brazil is. Instruments on combating deforestation and climate change can hopefully be better designed to address the major drivers of deforestation with this new knowledge; a few suggestions and recommendations on what could be done are described below.

5.2 Recommendations and Suggested Political Consequences

A worry is that the underlying drivers of deforestation in Brazil are not effectively addressed at the moment. These drivers will, however, most probably increase in the future as population grows, as demand for meat increases and as also international trade accelerates (Gottwald & Fischler, 2007). So, effective measures to halt or decrease deforestation are urgently needed. There are at least three levels where solutions to this global problem can attach: In Brazil itself, in the countries where demand-side pressure comes from, here especially the EU, and on the international level. Selected recommendations and political suggestions are therefore given for exactly these levels below.

5.2.1 Measures within Brazil

At first, there seems to be a need to make the existing laws and programmes in Brazil more effective. For example the goals for deforestation reduction should get tightened because for the Amazon, the goal set until 2017 has already been reached. Furthermore, within the Amazon and the Cerrado, only a small percentage is fully protected (see Chapter 1.3.3) and these protected areas are often far away from the agricultural frontier so not really endangered anyway (Nepstad et al., 2006a). Stronger protection measures would therefore be desirable. This goes together with a better law enforcement and more financial means for forest protection. A good system for real time deforestation detection called DETER has been installed in the Amazon now but people who deforest should as well get prosecuted then. Furthermore, such a system is crucially needed for the Cerrado (WWF UK, 2011).

There will also be agricultural expansion in Brazil in the coming years – fostered by the Brazilian government which for example wants to double Brazil's share in beef products on the global markets until 2018 (Greenpeace, 2009a). For soya, literature says that only very small gains in productivity are possible, so an increase in soya production will also lead to an expansion of its area (WWF UK, 2011). Nepstad et al. (2008), Macedo et al. (2012) and others suggest to use more abandoned and degraded cattle pastures, which seem to be quite abundant, rather than deforesting more and more. This would require governmental or state support with the enhancement of degraded soils, the modernisation of the agricultural sector as well as good agricultural practices so that land does not degrade so fast. For cattle, however, an increase of the density of the herd is possible and also intensive farming instead of extensive use of pastures (Macedo et al., 2012). Even though other aspects of sustainability need to be considered for intensification, like the demand of soya feed in cattle farms and the loss of CO_2-sequestration capacity in managed pastures among other negative effects of animal farming (Germanwatch & AbL, 2010), the effect of cattle on deforestation could possibly be lowered in the future.

Another suggestion of Nepstad et al. (2008) is to restrict forest clearings to those areas in the Amazon being classified as "suitable" (33 %) or "very suitable" (22 %) for mechanised agriculture which you can see in the map below (Figure 42).

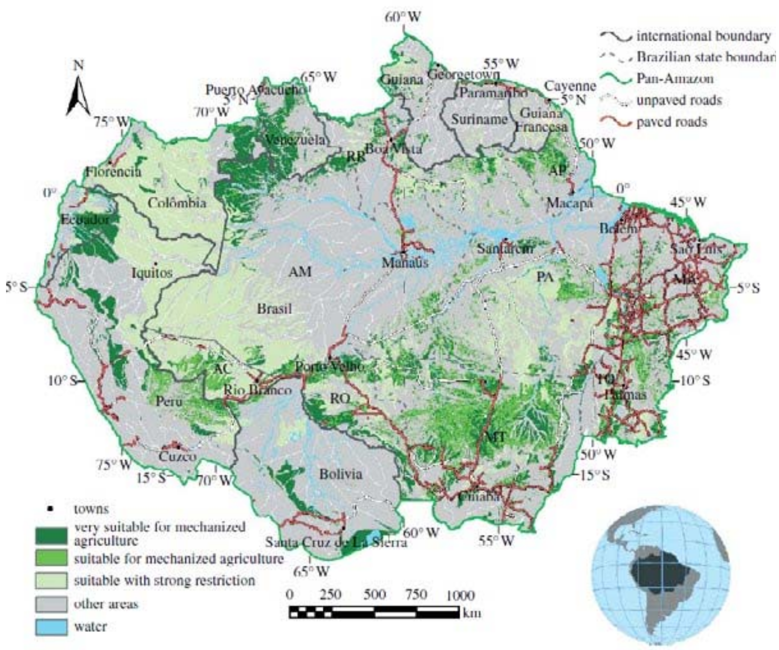


Figure 42: Areas within the Amazon where Mechanised Agriculture is Categorised as Being 'Suitable' or 'Very Suitable' (Nepstad et al., 2008, p. 1742, © Philosophical Transactions of the Royal Society B: Biological Sciences)

This suggestion is probably from a person who knows the region and who also witnessed that law enforcement has not been very effective in the past. Just protecting the areas which are not or little suitable for agriculture can save efforts and money and have a better chance of being successful because the area is not so big and the message to the farmers is that they will have better soils if they obey this law. Nevertheless, legally enabling deforestation in these agriculturally suitable areas seems to be just a last option if other measures do not work.

Another important aspect of Brazilian laws and programmes to reduce deforestation should be to avoid leakage and iLUC. Especially sugar cane, used as bioethanol, which is expanding rapidly in Brazil at the moment, and as has been shown soya include the risk of iLUC (Andrade de Sá et al., 2012; Lapola et al., 2010). Avoidance of leakage and iLUC could be done by national approaches on deforestation reduction, so not separately for the Amazon and the Cerrado for example, by countrywide emission accounting, by a closer collaboration of the cattle, soya and biofuel sectors as well as by more participatory processes. Also socio-economic aspects of the local population, indigenous rights, food security especially for smallholder farmers and measures to fight corruption should be considered in each new law.

The demand for environmentally-friendly and deforestation-free products has to come from the consumers in the EU, Russia, China and other countries. The farmers in Brazil are willing to comply with environmental laws and certify their products, e.g. through the RTRS, if they feel this demand and probably get a better price as well (e.g. Nepstad et al., 2008). In return, the signatories have to ensure full transparency and compliance with the voluntary agreement. In a study by Greenpeace (2011) they found out that some meat which was sold as certified under the beef moratorium was produced with slave labour and came from farms which got the cattle from other farms where deforestation happened. The Brazilian government as well as the importing countries should put more pressure on the reliability of the certified products.

5.2.2 Measures of the EU

The EU can stimulate the production of certified, deforestation-free products with its demand and imports as mentioned above. There is for example a sustainability standard for biofuels in the EU's renewable energy directive and the EU Timber Regulation to stop the import of illegally logged timber (see Reichert & Reichardt, 2011; Nellemann & INTERPOL, 2012). Regulations like that could be expanded for soya and cattle meat and thereby reduce the EU's impact on the Brazilian forests. Measures like this should take FLEGT, the voluntary partnership agreement of the EU with certain nations to stop the import of illegally logged timber and of which the Timber Regulation is a part of, as a good example because it does not intend to stop trade but helps the exporting country to fulfil the needs of the EU as an importer, helps in regulating illegal logging and supports good forest governance (Nellemann & INTERPOL, 2012).

The EU could also set itself broader sustainability goals. One possibility is to define emission reduction targets for its agricultural sector which could include the emissions from deforestation calculated in the study at hand. Another more comprehensive possibility is that the EU sets itself the goal to reduce its virtual land use. In 2010, the EU imported a net of 26 million hectares from around the world, in the years before it was even more than 30 million hectares a year, see also Figure 43. An EU-goal to reduce the import of virtual land yearly by a certain percentage would most likely also reduce the problems of deforestation, CO_2-emissions, pesticide use, land conflicts with the local population, land degradation and others associated with land use. And the calculation should not be too difficult as the WWF study (von Witzke et al., 2011) has shown.

Going together with a reduction in virtual land import is the increase in self supply of the EU with protein-rich animal feed. Suitable crops are available and partly planted already. Even soya can be planted within the EU (Agrar Koordination, 2012). However, these crops can just substitute impor-

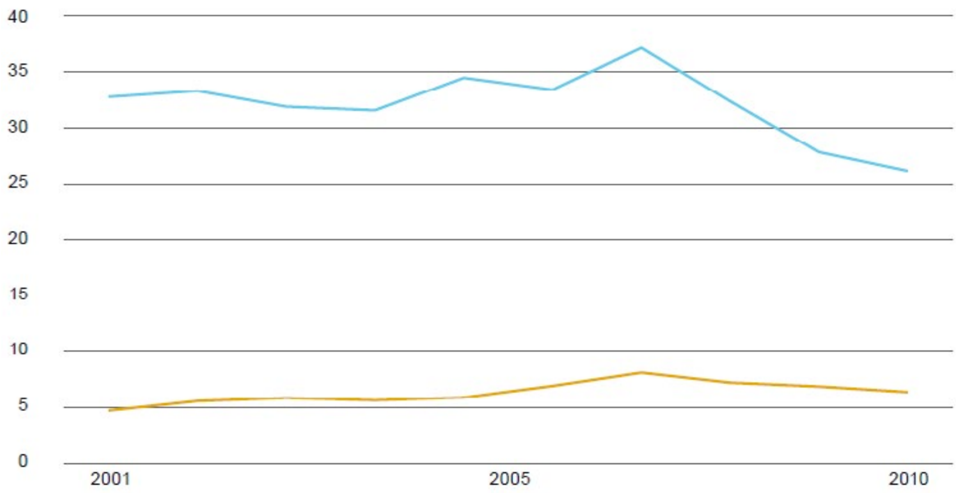


Figure 43: Virtual Land Imports by the EU (Blue) and Germany (Orange) through Agricultural Trade [Millions of Hectares] (von Witzke et al., 2011, p. 34, reproduced with permission from WWF)

ted soya partly because especially pigs and poultry need more protein-rich feed (WWF UK, 2011). There has been no real support for these crops in the EU within the last decades, so the planted area is quite low (Reichert & Reichardt, 2011; Agrar Koordination, 2012). Nevertheless, these protein-rich legumes have co-benefits for the nutrient enhancement of the soil and are therefore included into the crop rotation system by some farmers. In the course of the reform of the CAP, claims that each farmer should plant a mandatory percentage of legumes in order to get the full amount of agricultural subsidies have been made by a broad coalition of German NGOs (AG L&E, 2012). The catchphrase for this strategy is the "European Protein Strategy". An increase in the supply of the EU with regional animal feed would need support in terms of research, breeding of suitable and adapted species, consultancy and trainings because there is not too much knowledge among the farmers on these crops anymore.

Another aspect going with the reduction of soya imports by the EU is that it should reduce its meat exports which especially go to Africa. Therefore, policies supporting these exports should be abandoned (AG L&E, 2012). Without these exports, the demand of soya by the EU would already decrease by some percentages hence also its responsibility for deforestation in Brazil.

To reduce its impacts through cattle meat, the EU should also consider an awareness campaign within its member countries about reducing personal meat consumption. This would not only be good for Brazilian forests but also for everybody's health. At the moment, the Germans for example consume on average twice as much meat as the recommended 300 – 600 grams per week (von Witzke et al., 2011). Reducing meat consumption will also lead to less soya use and has thus a double benefit for deforestation reduction.

With all these measures aiming at less consumption or the substitution of environmentally-harmful goods by local or certified ones, the impact of the EU is reduced. However, there will probably just be a shift and the soya and meat from newly deforested areas will be exported to countries with less strict requirements. This is an argument for more measures addressing demand-driven deforestation at the global level as described in the next subchapter. Nevertheless, this argument is not valid when we look at it from a perspective of justice: then it is only a matter of equality that those countries which already consumed a lot decrease their demand and that others are allowed to increase it. This shall be no excuse for environmentally-destructive consumption by emerging markets but it should just get clear that the EU cannot really blame other countries with an increase of agricultural imports from Brazil hence an increasing impact on deforestation there.

5.2.3 Measures on the International Level

What comes to mind at first when thinking about forest protection at the international level is REDDplus. This instrument to financially support countries which do not deforest and to promote sustainable forestry is debated under the UNFCCC at the moment. Concerning its efficiency, it seems pretty obvious that the level of compensation needs to be as high as or even higher than the possible financial revenues from deforestation and use of the area. Due to the fact that prices for cattle meat and soya fluctuate, this seems to be really difficult. Furthermore, leakage is a big issue for REDDplus because production often just moves into other areas or countries. That is why at least a nationwide approach if not a global approach needs to be applied which monitors deforestation displacement as a result of forest protection (Meyfroidt et al., 2010). Supporting instruments like REDDplus and reducing demand-side pressure should both be fostered by the EU and other importing countries of agricultural products. If not, this would be very incoherent and work against each other.

Another financial aspect is that no loans should be given to the cattle and soya industry if there is the risk of deforestation. Existing instruments like the Equator Principles which have been signed by more than 80 % of all project-financing credit institutes worldwide, among them also four large Brazilian banks (Ibrahim et al., 2010), are very helpful if they are monitored well.

A crucial aspect that must be discussed in this study is the method of emission allocation because it seems not right that Brazil is blamed for its high GHG-emissions whereas other countries are vowed for their afforestation even though they displace a lot of land and deforestation to other countries. As Meyfroid et al. (2010) state, often the afforestation in these countries is not as ecologically valuable as those forests which get destroyed by displaced land use. So, the allocation method of GHG-emissions to producer countries needs to be reconsidered by the international community in favour of consumption-based accounting. Like this, emissions embedded in traded goods would be calculated and then accounted for the importing country. In this study, this has been done partly for emissions from deforestation. Other studies like the one by Davis & Caldeira (2010) include emissions from energy consumption and fossil fuels but left out the ones from deforestation for example. Thus, there are approaches on how consumption-based accounting could look like. This method would make the real underlying drivers of deforestation, like Russia and other countries from the so called “global North“, visible and show their responsibilities on deforestation, emissions and climate change. As a result, this would most probably trigger efforts by these countries in deforestation reduction and financial flows towards countries where deforestation is happening. However, this approach does not seem to be on the political agenda in the UNFCCC negotiations so far (Brickell, 2012).

Not including the embedded emissions at the country- but on the consumer-level could be realised with carbon taxes and thus the internalisation of external costs into the prices of products. This would potentially drive the global economic system towards more efficiency in land use for agricultural production. For this approach, also exact data on emissions of each product needs to be figured out. The study at hand has made a contribution towards this quantification.

5.3 Outlook

The methods used in this study to quantify direct and indirect deforestation in Brazil through the import of agricultural products and their deforestation emissions can also be applied for other countries and other agricultural products. Like this, future studies could quantify the EU’s impact on deforestation worldwide and the total embedded emissions in its imports. Of course, also the impacts of other importing countries can be calculated easily with the respective trade data from FAOSTAT.

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Appendix

Table 40: Importing Countries of Brazilian Cattle Meat with Import Quantity and Percentage of Total Brazilian Cattle Meat Exports, 2006 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	Russian Federation	317,434	26%
2	EU	313,989	26%
3	Egypt	198,147	16%
4	Algeria	47,329	4%
5	Iran (Islamic Republic of)	44,985	4%
6	Saudi Arabia	38,086	3%
7	Israel	30,656	3%
8	Philippines	27,883	2%
9	China	27,316	2%
10	Libya	20,611	2%
11	Lebanon	17,384	1%
12	Venezuela (Bolivarian Republic of)	13,536	1%
13	Ukraine	11,814	1%
14	Singapore	11,310	1%
15	United Arab Emirates	10,461	1%
16	Switzerland	9,084	1%
17	Angola	6,698	1%
18	Djibouti	6,563	1%
19	Bosnia and Herzegovina	5,696	0%
20	Croatia	5,517	0%
21	Chile	5,334	0%
22	The former Yugoslav Republic of Macedonia	5,322	0%
23	Kuwait	4,569	0%
24	Jordan	3,395	0%
25	Serbia	3,118	0%
26	Albania	3,077	0%
27	Malaysia	2,751	0%
28	Micronesia (Federated States of)	2,728	0%
29	Uruguay	2,603	0%
30	Côte d'Ivoire	2,590	0%
31	Gabon	2,190	0%
32	Ghana	1,930	0%
33	Netherlands Antilles	1,341	0%
34	Qatar	1,237	0%
35	Aruba	1,125	0%
36	Peru	1,110	0%
37	Tunisia	1,055	0%
38	Liberia	1,054	0%
39	Bahrain	886	0%
40	Turkey	811	0%
41	Georgia	761	0%
42	Norway	754	0%
43	Comoros	695	0%
44	Senegal	662	0%

	Importing Country	Value [t]	% of Total Exports
45	Namibia	576	0%
46	Equatorial Guinea	473	0%
47	Unspecified	425	0%
48	United States of America	394	0%
49	Congo	325	0%
50	Syrian Arab Republic	312	0%
51	Cape Verde	308	0%
52	Mozambique	287	0%
53	Iraq	274	0%
54	Haiti	255	0%
55	Latvia	250	0%
56	Sri Lanka	247	0%
57	Bermuda	184	0%
58	Democratic Republic of the Congo	173	0%
59	Oman	156	0%
60	Brunei Darussalam	138	0%
61	Maldives	136	0%
62	Guinea	109	0%
63	South Africa	104	0%
64	Suriname	101	0%
65	Grenada	88	0%
66	Gambia	87	0%
67	Afghanistan	76	0%
68	Mauritius	76	0%
69	Australia	75	0%
70	Kenya	70	0%
71	Armenia	51	0%
72	New Zealand	50	0%
73	Faroe Islands	47	0%
74	British Virgin Islands	26	0%
75	Argentina	25	0%
76	Canada	25	0%
77	Guatemala	25	0%
78	Seychelles	25	0%
79	United Republic of Tanzania	25	0%
80	Cameroon	24	0%
81	Republic of Korea	24	0%
82	Yemen	23	0%
83	Sao Tome and Principe	14	0%
84	Sierra Leone	13	0%
85	Nigeria	10	0%
	SUM of Exports	1,221,703	

Table 41: Importing Countries of Brazilian Cattle Meat with Import Quantity and Percentage of Total Brazilian Cattle Meat Exports, 2008 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	Russian Federation	381,967	38%
2	Venezuela (Bolivarian Republic of)	96,821	10%

	Importing Country	Value [t]	% of Total Exports
3	Iran (Islamic Republic of)	81,202	8%
4	Egypt	64,994	6%
5	China	63,789	6%
6	Algeria	48,247	5%
7	EU	38,245	4%
8	Saudi Arabia	35,710	4%
9	Israel	32,074	3%
10	Ukraine	25,354	2%
11	Libya	25,331	2%
12	Lebanon	18,787	2%
13	Philippines	14,083	1%
14	United Arab Emirates	11,765	1%
15	Angola	10,201	1%
16	Singapore	8,642	1%
17	Jordan	5,600	1%
18	Bosnia and Herzegovina	4,804	0%
19	Kuwait	4,720	0%
20	The former Yugoslav Republic of Macedonia	3,988	0%
21	Djibouti	3,645	0%
22	Unspecified	3,520	0%
23	Micronesia (Federated States of)	3,483	0%
24	Chile	2,574	0%
25	Croatia	2,161	0%
26	Malaysia	1,927	0%
27	Switzerland	1,766	0%
28	Netherlands Antilles	1,716	0%
29	Tunisia	1,579	0%
30	Qatar	1,578	0%
31	Albania	1,504	0%
32	Ghana	1,471	0%
33	Viet Nam	1,344	0%
34	Peru	1,315	0%
35	Uruguay	1,221	0%
36	Aruba	1,151	0%
37	Bahrain	888	0%
38	Armenia	775	0%
39	Gabon	768	0%
40	Côte d'Ivoire	697	0%
41	Senegal	629	0%
42	Turkey	622	0%
43	Equatorial Guinea	586	0%
44	Georgia	481	0%
45	Afghanistan	426	0%
46	Cape Verde	413	0%
47	Pakistan	361	0%
48	Maldives	281	0%
49	Liberia	238	0%
50	United States of America	218	0%
51	Iraq	202	0%

	Importing Country	Value [t]	% of Total Exports
52	Norway	179	0%
53	Congo	176	0%
54	Oman	166	0%
55	Democratic Republic of the Congo	148	0%
56	Seychelles	133	0%
57	Haiti	111	0%
58	Mauritania	108	0%
59	Namibia	100	0%
60	Comoros	91	0%
61	Mauritius	90	0%
62	Azerbaijan	75	0%
63	Sudan (former)	67	0%
64	Grenada	64	0%
65	Nigeria	54	0%
66	Sri Lanka	52	0%
67	South Africa	51	0%
68	Canada	50	0%
69	Guinea	46	0%
70	Bermuda	44	0%
71	Gambia	26	0%
72	Marshall Islands	25	0%
73	Mozambique	25	0%
74	Timor-Leste	25	0%
75	Cameroon	24	0%
76	Kyrgyzstan	18	0%
77	Iceland	14	0%
78	Sao Tome and Principe	12	0%
79	United Republic of Tanzania	12	0%
80	Guinea-Bissau	4	0%
81	Brunei Darussalam	3	0%
	SUM of Exports	1,017,857	

Table 42: Importing Countries of Brazilian Cattle Meat with Import Quantity and Percentage of Total Brazilian Cattle Meat Exports, 2010 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	Russian Federation	284,240	30%
2	Iran (Islamic Republic of)	191,181	20%
3	Egypt	113,228	12%
4	China	67,098	7%
5	EU	45,100	5%
6	Venezuela (Bolivarian Republic of)	40,125	4%
7	Algeria	30,144	3%
8	Saudi Arabia	29,882	3%
9	Israel	24,625	3%
10	Chile	19,902	2%
11	Lebanon	19,107	2%
12	Libya	16,259	2%
13	Philippines	11,630	1%

	Importing Country	Value [t]	% of Total Exports
14	Jordan	8,529	1%
15	United Arab Emirates	8,394	1%
16	Iraq	4,848	1%
17	Singapore	4,547	0%
18	Ukraine	3,691	0%
19	Angola	3,689	0%
20	Kuwait	3,688	0%
21	Unspecified	1,792	0%
22	The former Yugoslav Republic of Macedonia	1,707	0%
23	Tunisia	1,492	0%
24	Switzerland	1,480	0%
25	Albania	1,464	0%
26	Qatar	882	0%
27	Netherlands Antilles	835	0%
28	Aruba	722	0%
29	Armenia	615	0%
30	Syrian Arab Republic	599	0%
31	Peru	494	0%
32	Georgia	469	0%
33	Viet Nam	440	0%
34	Djibouti	438	0%
35	Malaysia	411	0%
36	Bahrain	395	0%
37	Azerbaijan	324	0%
38	Congo	321	0%
39	Cape Verde	314	0%
40	Turkey	289	0%
41	Gabon	246	0%
42	Cuba	221	0%
43	Croatia	213	0%
44	Senegal	156	0%
45	Micronesia (Federated States of)	154	0%
46	Bosnia and Herzegovina	139	0%
47	Equatorial Guinea	133	0%
48	Oman	133	0%
49	Japan	100	0%
50	Norway	96	0%
51	Liberia	89	0%
52	Comoros	68	0%
53	Mauritius	50	0%
54	Seychelles	50	0%
55	Uruguay	50	0%
56	Guinea	46	0%
57	Kenya	38	0%
58	Côte d'Ivoire	37	0%
59	Yemen	34	0%
60	Tajikistan	26	0%
61	Mauritania	25	0%
62	Morocco	25	0%

	Importing Country	Value [t]	% of Total Exports
63	Trinidad and Tobago	25	0%
64	Bermuda	24	0%
65	United Republic of Tanzania	24	0%
66	Maldives	13	0%
67	Benin	12	0%
68	Haiti	12	0%
69	Mali	11	0%
70	Pakistan	10	0%
71	Democratic Republic of the Congo	5	0%
72	United States of America	3	0%
73	Sudan (former)	2	0%
	SUM of Exports	947,660	

Table 43: Export Quantities and Proportions of Brazilian Cattle Meat Exported to China and the Russian Federation (own calculations, data from FAOSTAT, 2012)

	Cattle Meat Exported to China, carcass weight [t]	% of Brazilian Production to China	Cattle Meat Exported to Russia, carcass weight [t]	% of Brazilian Production to Russia
2000	16,447	0.25%		
2001	20,844	0.31%		
2002	20,166	0.28%		
2003	27,944	0.39%		
2004	33,376	0.43%		
2005	32,041	0.37%		
2006	39,023	0.43%	453,931	5.03%
2007	57,409	0.62%		
2008	91,127	1.01%	546,213	6.05%
2009	145,249	1.55%		
2010	95,854	1.05%		

Table 44: Importing Countries of Brazilian Soya Beans with Import Quantity and Percentage of Total Brazilian Soya Bean Exports, 2006 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	China	11,295,900	45%
2	EU	9,935,501	40%
3	Iran (Islamic Republic of)	928,809	4%
4	Thailand	767,080	3%
5	Republic of Korea	601,531	2%
6	Norway	373,781	1%
7	Japan	220,251	1%
8	Bolivia (Plurinational State of)	211,920	1%
9	Turkey	174,151	1%
10	United Arab Emirates	160,283	1%
11	Morocco	102,294	0%
12	Venezuela (Bolivarian Republic of)	53,451	0%
13	Israel	48,806	0%
14	Argentina	38,575	0%
15	Croatia	24,771	0%
16	Syrian Arab Republic	7,441	0%

	Importing Country	Value [t]	% of Total Exports
17	Paraguay	7,395	0%
18	United States of America	5,823	0%
19	Cuba	126	0%
20	Angola	84	0%
21	Mexico	2	0%
22	Uruguay	1	0%
	SUM of Exports	24,957,976	

Table 45: Importing Countries of Brazilian Soya Beans with Import Quantity and Percentage of Total Brazilian Soya Bean Exports, 2008 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	China	12,011,563	49%
2	EU	8,909,875	36%
3	Thailand	1,106,163	5%
4	Republic of Korea	512,505	2%
5	Japan	497,668	2%
6	Norway	403,882	2%
7	Morocco	181,329	1%
8	Switzerland	134,304	1%
9	Russian Federation	123,152	1%
10	Turkey	119,673	0%
11	Australia	94,806	0%
12	Israel	72,925	0%
13	Iran (Islamic Republic of)	68,500	0%
14	Cayman Islands	53,805	0%
15	Bolivia (Plurinational State of)	52,941	0%
16	Bangladesh	41,565	0%
17	Croatia	39,748	0%
18	Saudi Arabia	22,261	0%
19	Egypt	18,260	0%
20	Democratic People's Republic of Korea	8,112	0%
21	Indonesia	7,760	0%
22	Paraguay	4,831	0%
23	Colombia	4,384	0%
24	Unspecified	2,500	0%
25	Venezuela (Bolivarian Republic of)	1,794	0%
26	Algeria	1,453	0%
27	Singapore	1,255	0%
28	India	1,000	0%
29	United States of America	849	0%
30	Guatemala	140	0%
31	Angola	139	0%
32	Philippines	103	0%
33	South Africa	103	0%
34	Uruguay	55	0%
35	Cuba	52	0%
36	Malaysia	21	0%
37	Argentina	14	0%

	Importing Country	Value [t]	% of Total Exports
38	Canada	0	0 %
39	Namibia	0	0 %
	SUM of Exports	24,499,490	

Table 46: Importing Countries of Brazilian Soya Beans with Import Quantity and Percentage of Total Brazilian Soya Bean Exports, 2010 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	China	16,486,729	64 %
2	EU	5,870,063	23 %
3	Thailand	1,138,357	4 %
4	Japan	507,332	2 %
5	Republic of Korea	445,544	2 %
6	Russian Federation	388,571	2 %
7	Norway	358,069	1 %
8	Turkey	220,402	1 %
9	Saudi Arabia	140,705	1 %
10	Iran (Islamic Republic of)	58,099	0 %
11	Bangladesh	52,784	0 %
12	Croatia	51,482	0 %
13	Mexico	49,532	0 %
14	Morocco	28,604	0 %
15	Israel	24,639	0 %
16	Uzbekistan	24,328	0 %
17	Paraguay	5,798	0 %
18	Ghana	3,000	0 %
19	Venezuela (Bolivarian Republic of)	2,900	0 %
20	Indonesia	2,297	0 %
21	Singapore	1,129	0 %
22	Mozambique	100	0 %
23	United States of America	100	0 %
24	Philippines	81	0 %
25	South Africa	41	0 %
26	British Virgin Islands	34	0 %
27	Malaysia	21	0 %
28	Côte d‘Ivoire	20	0 %
29	Sudan (former)	10	0 %
30	Colombia	7	0 %
31	Angola	4	0 %
32	Bolivia (Plurinational State of)	2	0 %
33	Cape Verde	1	0 %
	SUM of Exports	25,860,785	

Table 47: Importing Countries of Brazilian Cake of Soya Beans with Import Quantity and Percentage of Total Brazilian Cake of Soya Bean Exports, 2006 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	EU	8,254,265	67 %
2	Thailand	1,208,194	10 %
3	Iran (Islamic Republic of)	592,678	5 %

	Importing Country	Value [t]	% of Total Exports
4	Republic of Korea	498,037	4%
5	Australia	405,735	3%
6	Indonesia	393,008	3%
7	Saudi Arabia	368,280	3%
8	Norway	228,182	2%
9	Viet Nam	57,944	0%
10	Chile	56,067	0%
11	Croatia	54,540	0%
12	Japan	50,987	0%
13	Venezuela (Bolivarian Republic of)	44,115	0%
14	Egypt	39,680	0%
15	Turkey	23,014	0%
16	New Zealand	19,022	0%
17	Colombia	18,697	0%
18	China	15,962	0%
19	Guyana	1,168	0%
20	Israel	1,127	0%
21	Uruguay	536	0%
22	Ecuador	412	0%
23	Argentina	260	0%
24	Honduras	250	0%
25	Cape Verde	108	0%
26	Canada	44	0%
27	Angola	27	0%
28	India	11	0%
	SUM of Exports	12,332,350	

Table 48: Importing Countries of Brazilian Cake of Soya Beans with Import Quantity and Percentage of Total Brazilian Cake of Soya Bean Exports, 2008 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	EU	9,263,238	75%
2	Thailand	730,740	6%
3	Republic of Korea	607,402	5%
4	Indonesia	426,684	3%
5	Australia	277,139	2%
6	Iran (Islamic Republic of)	252,909	2%
7	Saudi Arabia	183,367	1%
8	Cuba	129,738	1%
9	Croatia	124,106	1%
10	Russian Federation	80,496	1%
11	Viet Nam	72,730	1%
12	Norway	42,722	0%
13	Colombia	30,348	0%
14	New Zealand	30,012	0%
15	Turkey	10,000	0%
16	Switzerland	9,428	0%
17	Libya	3,500	0%
18	Unspecified	3,500	0%

	Importing Country	Value [t]	% of Total Exports
19	South Africa	2,795	0%
20	Ukraine	1,530	0%
21	Cameroon	1,033	0%
22	Lebanon	1,000	0%
23	Uruguay	752	0%
24	Honduras	650	0%
25	China	650	0%
26	Angola	327	0%
27	Senegal	246	0%
28	Japan	220	0%
29	Cape Verde	184	0%
30	Côte d'Ivoire	160	0%
31	Argentina	107	0%
32	Ghana	90	0%
33	Chile	56	0%
34	Guinea	36	0%
35	Bolivia (Plurinational State of)	1	0%
	SUM of Exports	12,287,896	

Table 49: Importing Countries of Brazilian Cake of Soya Beans with Import Quantity and Percentage of Total Brazilian Cake of Soya Bean Exports, 2010 (own calculations, data from FAOSTAT, 2012)

	Importing Country	Value [t]	% of Total Exports
1	EU	9,474,479	69%
2	Thailand	1,324,428	10%
3	Republic of Korea	962,689	7%
4	Indonesia	590,279	4%
5	Viet Nam	391,901	3%
6	Iran (Islamic Republic of)	262,993	2%
7	Cuba	254,423	2%
8	Saudi Arabia	141,829	1%
9	Croatia	114,136	1%
10	Japan	72,174	1%
11	Norway	42,155	0%
12	Russian Federation	15,195	0%
13	Dominican Republic	14,950	0%
14	Turks and Caicos Islands	3,730	0%
15	Colombia	828	0%
16	Uruguay	729	0%
17	Australia	608	0%
18	Chile	421	0%
19	Cameroon	241	0%
20	Argentina	132	0%
21	Albania	104	0%
22	Cape Verde	60	0%
23	Guatemala	41	0%
24	Mexico	22	0%
25	India	20	0%
26	New Zealand	17	0%

	Importing Country	Value [t]	% of Total Exports
27	Peru	14	0%
28	Bolivia (Plurinational State of)	1	0%
29	Paraguay	0	0%
	SUM of Exports	13,668,599	

Table 50: Export Quantities and Proportions of Brazilian Soya Exported to China (own calculations, data from FAOSTAT, 2012)

	Export of Soya Beans to China [t]	Exports of Cake of Soya Beans to China [t]	Export to China Total [t]	% Exported to China Total
2000	1,897,975	67,721	1,965,696	6%
2001	3,451,943	313	3,452,256	9%
2002	4,334,399	197	4,334,596	10%
2003	6,657,634	214	6,657,848	13%
2004	6,519,009	242	6,519,251	13%
2005	7,667,386	5,124	7,672,510	15%
2006	11,295,900	15,962	11,311,862	22%
2007	10,287,987		10,287,987	18%
2008	12,011,563	650	12,012,213	20%
2009	16,507,849	1,635	16,509,484	29%
2010	16,486,729		16,486,729	24%

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