Sustentabilidade em Debate

Towards a low carbon economy in the Amazon: the role of land-use policies

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Received: 03.03.2011
Accepted: 29.11.2011

Palavras-chave: emissões de gases de efeito estufa, agricultura, desmatamento, Brasil, pecuária, soja, políticas de conservação

RESUMO

As mudanças climáticas, a elevação dos preços do petróleo e a crise financeira global colocaram a sustentabilidade e o "crescimento verde" da economia na agenda política. A transição para uma economia de "baixo carbono" em países desenvolvidos, como na União Européia, vem sendo buscada principalmente pela geração de energia renovável. Já os países em desenvolvimento, como o Brasil enfrentam um aumento das emissões como resultado das mudanças no uso da terra, que deverá crescer ainda mais crescimento nas próximas décadas, se não forem adotados instrumentos de política adequadamente. O desmatamento e a pecuária são as principais fontes de emissões pelo uso da terra no Brasil e estas emissões devem crescer ainda mais com com a liberalização do comércio agrícola. A transição para uma economia de "baixo carbono" no Brasil, portanto, exige políticas de uso da terra adequadas. A intensificação da agricultura pode, por um lado satisfazer a demanda mundial por soja e carne bovina. Por exemplo, estimou-se que a intensificação da produção de gado pode reduzir emissões de desmatamento em até 30%, mas essa intensificação pode também acelerar o desmatamento das florestas do Cerrado e da Amazônia. Para evitar o desmatamento adicional, grandes áreas de terras degradadas devem ser reincorporadas à produção, o que requer grandes investimentos agrícolas. Além disso, (novos) instrumentos econômicos, monitoramento, aplicação da lei e políticas de conservação apropriadas também são necessários para deter o desmatamento e perda de biodiversidade. A mudança recente do Código Florestal, por exemplo, deve acelerar ainda mais o desmatamento, tornando assim mais difícil alcançar as metas de mitigação estabelecidas pelo Estado brasileiro.

Keywords:greenhouse gas emissions, agriculture, deforestation, Brazil, cattle, soy, conservation policies

ABSTRACT

Climate change, rising oil prices and the global financial crisis has put sustainability and 'green growth' of the economy on the political agenda. While the transition towards a "low carbon" economy in developed countries like in the European Union should mainly be found in renewable energy production, developing countries like Brazil face with high land use emissions which will further rise in the coming decades without proper policy instruments. Deforestation and cattle production are the main sources of land use emissions in Brazil and we expect that these emissions will further rise with liberalisation of agricultural trade. A transition towards a "low carbon" economy in Brazil thus calls for appropriate, and effective land-use policies. Agricultural intensification on one hand can meet the world demand for soy and beef. For example we calculate that increasing the meat content of cattle can reduce emissions from deforestation up to 30%, but intensification may also accelerate further deforestation of Cerrado and Amazon forests. In order to avoid such additional deforestation, large areas of degraded lands have to be taken back into production, which requires large agricultural investments. In addition, (new) economic instruments, monitoring, law enforcement and appropriate conservation policies are also needed to halt further deforestation and biodiversity loss. The recently amended change of the Forest Code policy, for example, is expected to accelerate deforestation further, thus making more difficult to reach mitigation targets for the Brazilian State.

1. Introduction

Climate change, rising oil prices and the global financial crisis in the first decade of the new 21nd century has put sustainability again on the political agenda. In the beginning of the financial crisis, started end of 2008, several EU countries called for a new 'green growth' of the economy as a response to the collapse of the economic system. Just before this crisis, the late German politician Scheer argued for solar energy as a solution to oil dependency and a path towards a fossil free energy production (e.g. Scheer, 2006). Due to Scheers' strong lobby in parliament, he was one of the initiators of the German feed-in tariffs for solar energy, giving a strong boost for renewable energy production in this country.

Despite this success, EU initiatives in greening the economy are foundered on budgetary cutbacks of governments due to the financial support to the bank sector. This also illustrates the difficulties facing developed countries, like those in the EU; the transition towards a low carbon economy depends on huge investments and those investments have to last for a number of decades.

Comparing the energy budget of the EU with Brazil, for example, shows that within the EU about 80% of carbon emissions stem from energy consumption (Figure 1), while in Brazil land use is responsible for about 74% of all carbon emissions. Emission profiles in both EU and Brazil show to be rather constant. In 1970 the differentiation in emission sources did not differ much of those in 2010. While in the EU emissions per capita decrease due to energy efficiency measures, Brazil still show an increase in emissions per capita. In the EU a further emission reduction is likely to come from transitions towards renewable energy production such to initiate a low carbon economy using both governmental and private budgets for alternative energy sources. In countries like Brazil a search for an innovative land use approach to cut back emissions is a likely transition for the coming decade.

In this paper the role of land use policies is illustrated to reduce greenhouse gases in Brazil and suggestions for a transition towards a low carbon economy and green growth are given.

2. Projections on emission efficiency

A low carbon economy can be defined as the "lowest" amount of carbon emitted per dollar earned (see website World Bank). Figure 2 uses this definition to illustrate that total EU emissions efficiency gradually increase over time, while European land use emission efficiency varies from 0.17 kg C.US^{-1} in 1970 to 0.07 kg C.US^{-1} in 2010 (data not shown). Since energy consumption causes the high 'carbon footprint' in the EU, the observed decline is mostly caused by efficiency measures. Machines, cars and other (household) equipment use less energy than twenty years ago, but this efficiency transition is coming to its end and not much more energy efficiency can be realized. In addition, some EU countries, like France and Finland, have shifted to nuclear power for energy supply, reducing CO_2 emissions.

Brazil emissions vary greatly in efficiency and emission source. The emissions efficiency shows periodic peaks and those are caused by land use emissions only (data not shown). The cause behind this high carbon emission per US$ are found with oscillating and high deforestation rates. A trend analysis shows that these deforestation patterns in eight Amazonian states are correlated to international beef and soy prices (Figure 3), but local immigration rates into Amazon forest also results

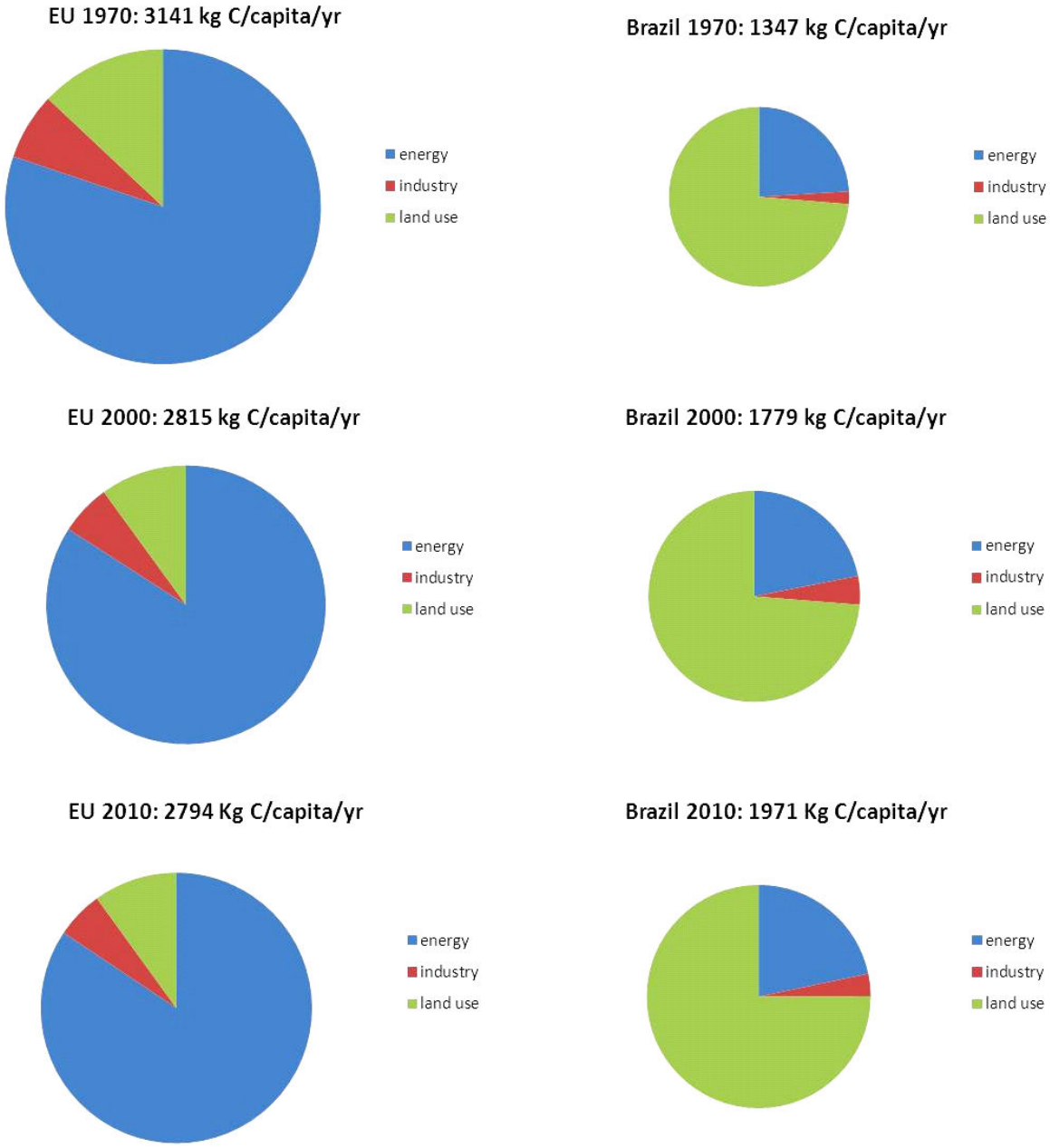

Figure 1: Emission profiles from different sectors (energy production, industry and land use – mainly agriculture) in 1970, 2000 and 2010 in member states of the European Union and in Brazil. Emissions are denoted as kg C.capita^{-1}.year^{-1}. Data: recalculations from Verburg et al. (2009).

in high deforestation (see Verburg et al., in prep). The increase demand for beef and soy thus may help to drive agricultural expansion and subsequent land clearing (e.g., Van Meijl *et al.*, 2006; Verburg *et al.*, 2009).

As China is seen as the labour factory of the world, Brazil is becoming the agricultural one. Indeed, in a study on agricultural trade liberalisation Verburg *et al.* (2009) showed that liberalisation would further increase cattle and soy production in Brazil. Emission efficiency projections as depicted in Figure 2 show for both EU and Brazil a gradual increase in efficiency (and thus lower emissions) in a baseline scenario that includes no new (trade) policies. Trade liberalisation of the agricultural sector, however, will decrease Brazil emissions efficiency (and thus increase emissions) considerably. This lower emission efficiency is due

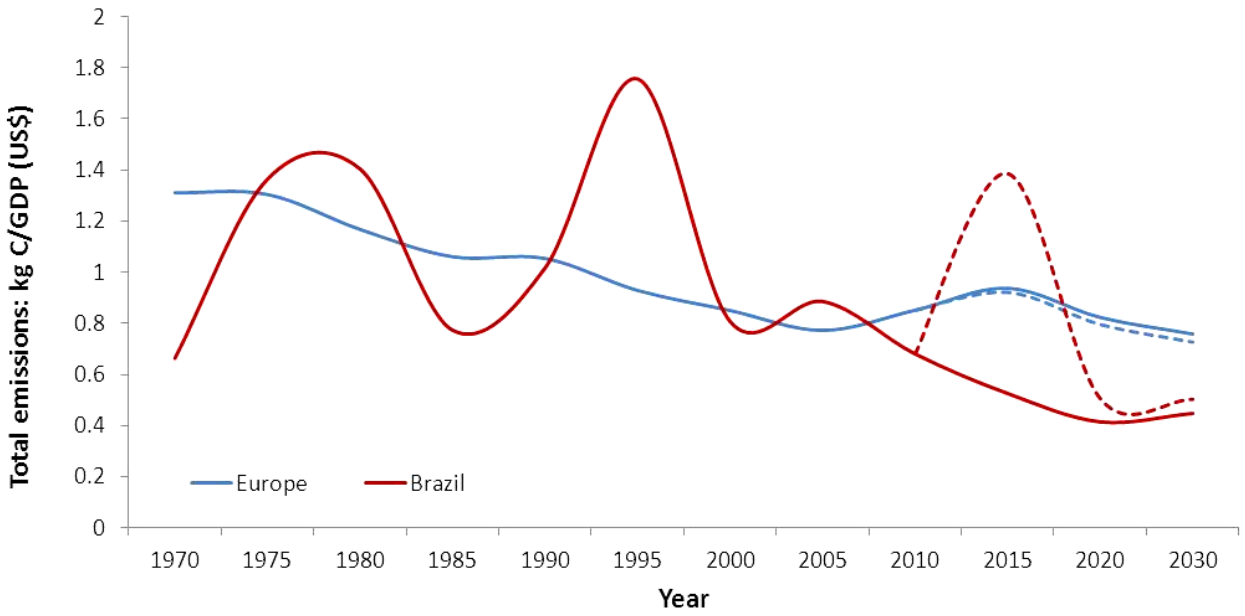

Figure 2: Emission efficiency (in kg C.GDP^{-1}) in Europe and Brazil between 1970 and 2010 and projections up to 2030 for a baseline scenario assuming no new policies (continued solid lines) and a trade liberalisation scenario of the agricultural sector after 2015 (dashed lines). Emission efficiency calculated as total emissions.capita^{-1}/GDP US$.capita^{-1}. GDP in constant 2000 US$. Data recalculated from Verburg et al. (2009).

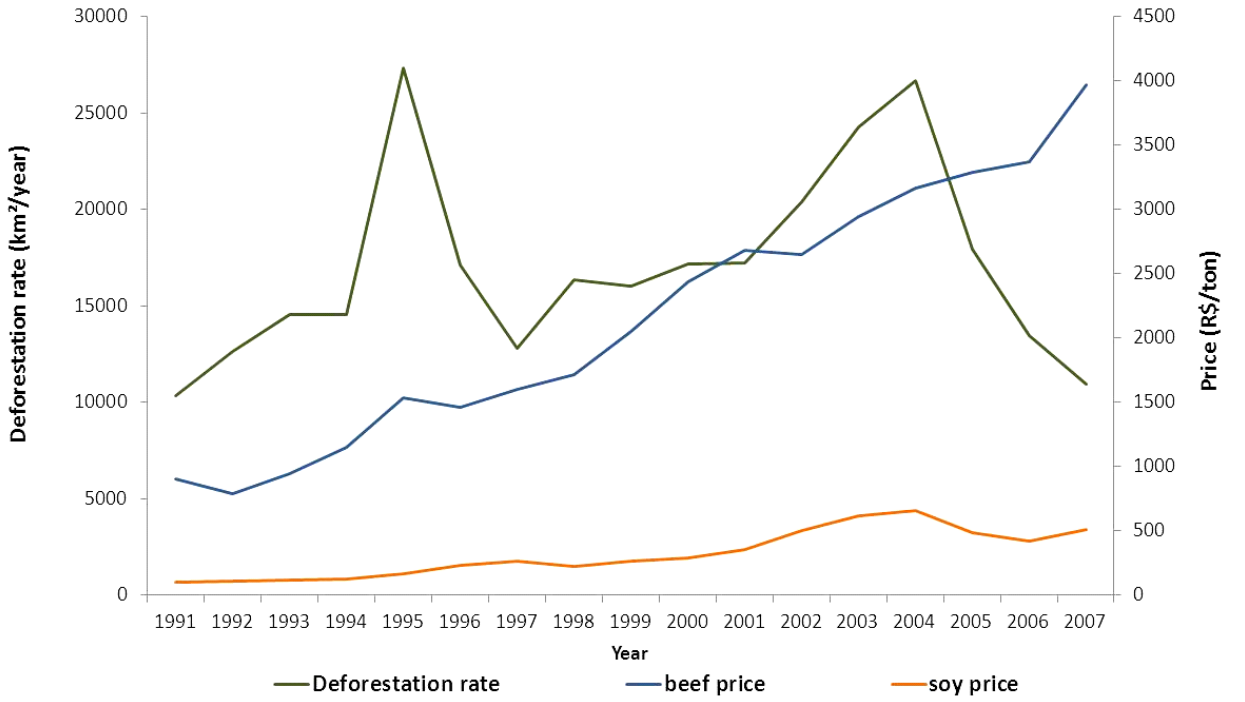

Figure 3: Aggregated deforestation rates in the Brazilian states of *Acre*, *Amazonas*, *Amapá*, *Pará*, *Rondônia*, *Roraima*, *Tocantins* and *Mato Grosso* (left axis) and corresponding beef and soy prices (in Reals per ton, right axis).

to further deforestation and land clearing for world demand of beef and soy.

Increasing demands for beef and soy are assumed to be caused by the interplay of three factors: increasing world population, increasing regional GDP and changing diets towards the intake of more animal proteins. Trade liberalisation is assumed to benefit technology transfer and in-

crease regional GDP more than proportionally. As Westhoek *et al.* (2011) show, increasing GDP usually leads to a food habit more comparable to industrialized countries like those in the EU or in the USA. Hence, open markets stimulate consumption of more animal proteins (meat) and consequently a larger demand for beef. As meat production in the EU becomes more dependent on imported animal feed, the demand for soy also increases. The study of Verburg *et al.* (2009), however, assumed a 'zero-sum' game; no additional GDP and consumption effects were taken into account. In this study, world emissions did not differ largely between the baseline and a trade-liberalisation scenario, but large regional shifts in emissions were found, most pronounced by Brazil's land use changes and caused by abandonment of trade tariffs and subsidies only. These results suggest that land use changes in Brazil have a very strong international component and argumentation rise that emissions reduction should solely focussed on this international aspect. However, agricultural production efficiency and (local) land use policies may still play a crucial role reducing emissions towards a low carbon economy.

3. Agriculture and deforestation: an example from a case study

Pavement of several highways that cut the Amazon biome is part of a project to integrate the Brazilian road system with that of other countries in South America, such as Chile and Peru, allowing Brazilian products to have access to ports on the Pacific. According to Soares-Filho *et al.* (2004) and others, the paving of highways causes an increase in the rates of deforestation and opens new fronts for occupation. Pavement of road BR-163 is part of this plan and will connect agricultural areas in Mato Grosso to the port of Santarém in Pará with a connection to the Atlantic Ocean. Along this road an agricultural frontier is under development, emerging from the centre of Mato Grosso into the state of Pará (see Figure 4). This agricultural frontier was subject to an EU funded integrated research program called LUPIS (Land Use policies and sustainable development in developing countries) and comprised of eleven municipalities differing in agricultural development (see Rodrigues Filho *et al.*, 2010).

Emission sources within this case study area are mainly from three sources, of which deforestation is by far the largest one (Figure 5). High CO_2 emissions from deforestation are due to the expansion of the agricultural frontier within the State of Pará. In the consolidated agricultural area in Mato Grosso the main source of emissions is cattle raising (data not shown), since deforestation is of less importance beyond 2005. This is due to the fact that natural forest area has almost disappeared in this part of the study area and strong land competition occurs between cattle and crop farming leading to a push of cattle farmers further into the Amazon rainforest. In the case study area deforestation and land clearing is primarily driven by the international demand for beef and soy and to local immigration patterns (e.g., Verburg et al. in prep). In addition exported soy to the EU is mainly used as animal feed (Kamphuis *et al.*, 2010).

3.1 Climate change policy – articulating conservation and development

Land use policies for the North of Mato Grosso and southeast of Pará are centred on agricultural development and coexist with conservation policies (Rodrigues Filho *et al.*, 2010). Launched in 2004, the Action Plan for Protection and

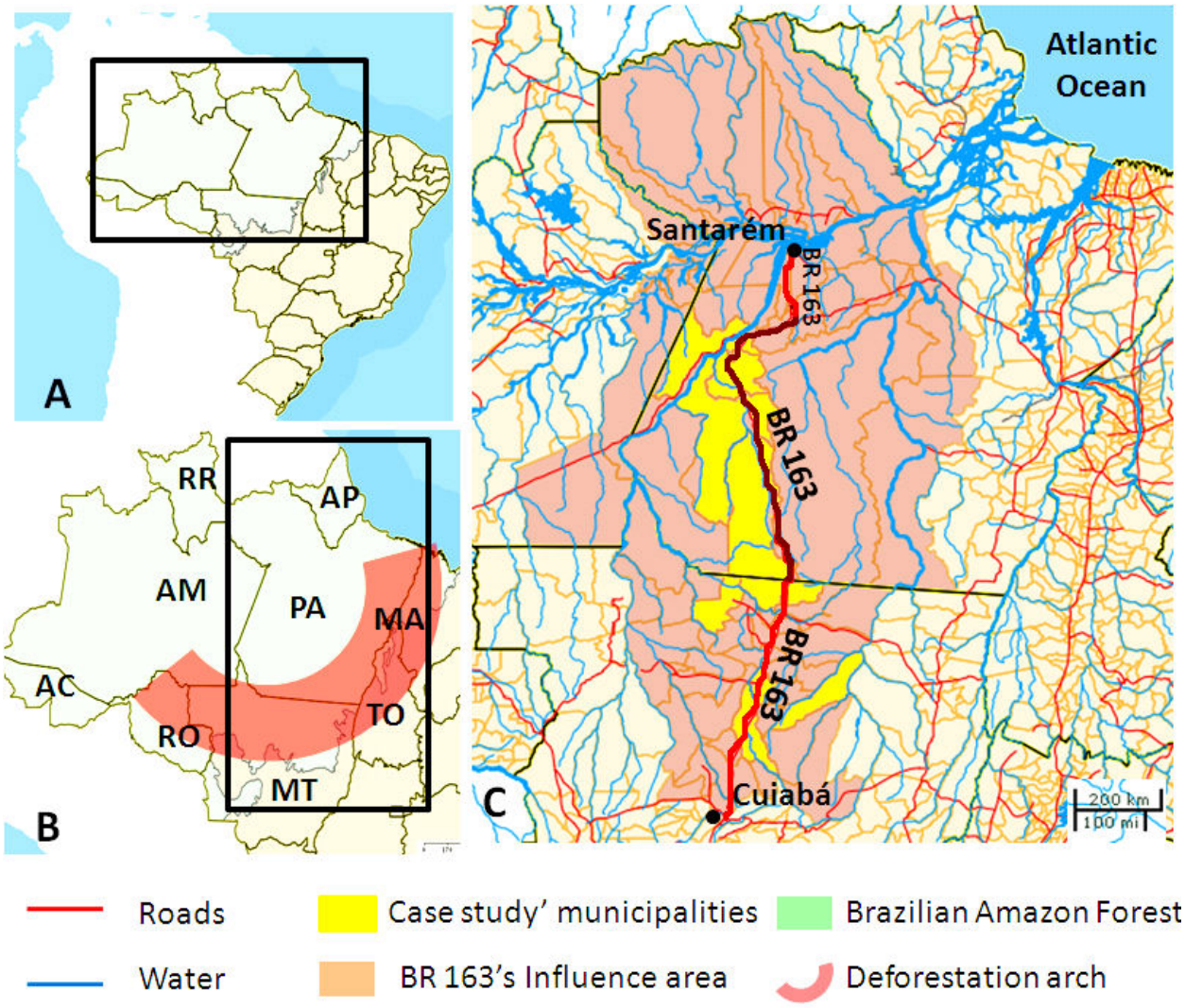

Figure 4: **(A)** Location of Brazilian Amazon within South America and Brazil. **(B)** States covered by Amazon Forest (**AM**: Amazonas; **AC**: Acre; **AP**: Amapá; **MA**: Maranhão; **MT:** Mato Grosso; **PA**: Pará; **RO**: Rondônia; **RR:** Roraima; **TO:** Tocantis). Deforestation Belt highlighted in light red. **(C)** Location of Municipalities studied in the LUPIS project (yellow) along BR 163 highway within Mato Grosso (*Sorriso, Sinop, Feliz Natal, Gurantã do Norte, Alta Floresta, Novo Mundo* and *Marcelândia*) and Pará (*Novo Progresso, Rurópoilis, Trairão, Itaituba*). The paved stretch is in red and the unpaved one in dark brown. The Santarém Harbor is shown is Amazon riverside (source: elaborated using i3Geo tool provided by MMA, 2011).

Control of Deforestation in the Amazon (PPCDAM) comprises a large number of initiatives which encompass territorial planning, land tenure regularization, monitoring and surveillance, as well as the promotion of sustainable forestry management. Since its implementation, PPCDAM has been accompanied by a significant drop in deforestation rates, of 59% over the period 2005-2007, the creation of 20 million hectares of conservation units in the Amazon region, and other 10 million hectares of indigenous lands. Other examples of Brazilian efforts aimed at combating illegal deforestation in the Amazon include the implementation of frameworks for management of Public Forests, which were recently introduced in Brazil's legal system through Act N.º 11,284, of 2006. PPCDAM initially comprised 13 ministries of the federal government, under direct coordination of the President's Chief of Staff. In spite of the fact that Brazil is experiencing a pe-

riod of expressive economic growth since 2004, in August 2010 the country reached the lowest annual rate of deforestation since the beginning of its 21- year history of deforestation monitoring. There will be necessary further management instruments to ensure the effectiveness in controlling forest loss, such as economic incentives for environmental conservation, recovering of degraded areas. However, the ineffective presence of the State institutions, associated with corruption of institutional personnel and an economic context (national and international) that favours the expansion of the agricultural frontier, results in a close correlation between deforestation and regional economic growth; the latter process at the expense of increased deforestation. The climate change agenda is an opportunity to go beyond this dilemma. However, while the debate and political actions to the region are still restrained to mechanisms of deforestation control, few advances will held in this direction.

The national policy on climate change (Law 12.187/2009) became an important instrument, as it establishes clear targets to reduce Brazilian GGEs between 36.1% and 38.9% in relation to the emissions projected to 2020. At the same time more than 80% of the targets will be realized through the reduction of deforestation in the Amazonia and Cerrado, as well as by the intensification of agribusiness.

Considering that the agribusiness expansion toward the forest and Cerrado was the highest along the BR 163 highway axis, in the last decades, mitigation efforts along the highway may represent a great contribution to Brazil to meet the county's mitigation targets for 2020. Connecting both conservation policies and development policies is urgent and should guide future actions for the region.

3.2 Conservation policies

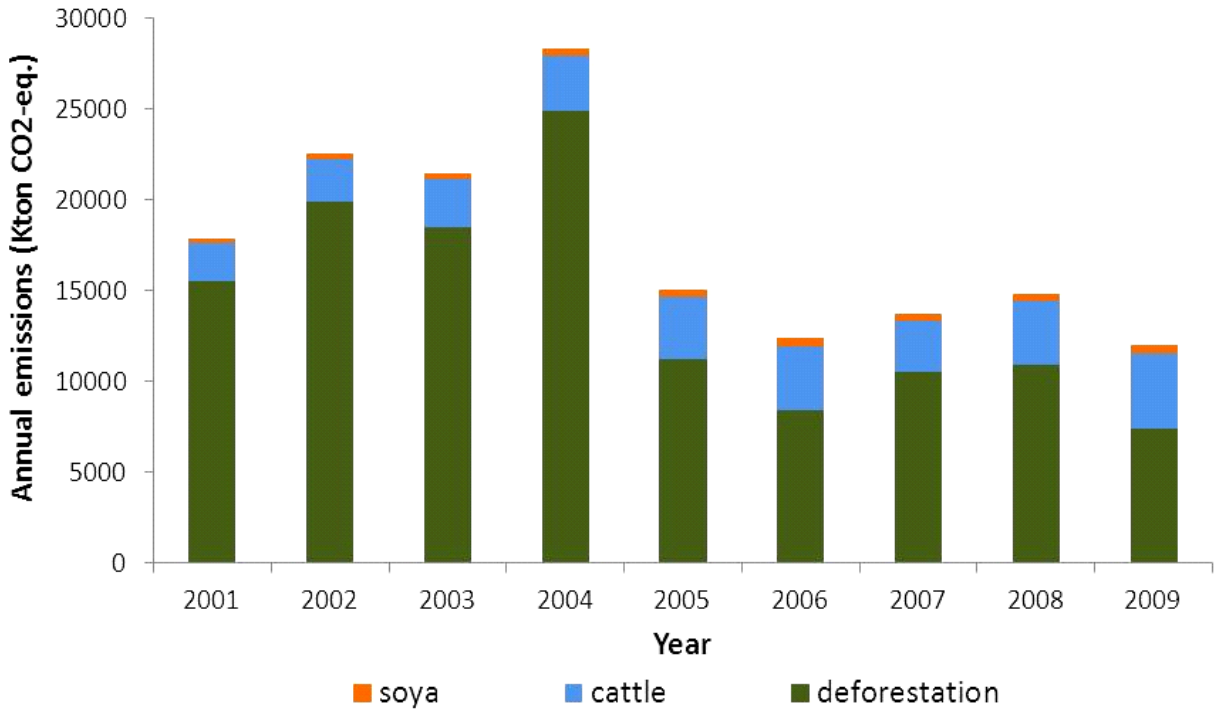

Figure 5: Annual land use emissions (in kton CO_2-eq.) in the case study area of eleven municipalities with emission source. Green: CO_2 from deforestation; Blue: CH_4 from cattle raising; Orange: N_2O from soy.

Aspects of climate change are indirectly inserted into the creation of Conservation Units and indigenous territories, since this favours the preservation of the forest and its role as a sink for carbon and a reservoir of water within the water cycle of the continent (Fearnside *et al.*, 2009; Marengo, 2006; Nobre and Nobre, 2002). However, such policies are not comprehensive enough and lack integration; policies are often not respected, due to the fragility of control actions. And if so, there is no guarantee that the fragmentation of the forest in several mosaics of legally protected areas will guarantee the preservation of the Amazon biodiversity and the essential ecological functions to maintain the climactic balance for the region and for the planet. Nonetheless, there is evidence of its contribution on slowing down deforestation in the 'arch'.

The conservation of natural reserve sites (Conservation Units) and the Forest Code policy, if effectively uphold, has shown to reduce greenhouse gas emissions from deforestation (Verburg et al., in prep). The Forest Code policy, which is an environmental legislation, was amended in 1965. From 2000 onwards, eighty per cent of a rural property in the Amazon region should be left intact as a legal reserve (Law 9,985, as of July 18, 2000). However, the problems of surveillance in remote areas, and associated corruption mean that illegal logging prevails (Rodrigues et al., 2009).

The Forest Code has become very recently a central topic in a hot social debate, even followed in Europe. The Code was revisited by the Brazilian Parliament in May 2011. Today, it is expected that less forest area will be protected by the code, leading to larger agricultural areas in the rural properties and enhanced land based greenhouse gas emissions.

3.3 Agricultural intensification

The difference between potential and actual yields of agricultural production is referred to as the 'yield gap'. Estimates show that this yield gap is large in many regions of the world, and particularly in sub-Saharan Africa (IAC, 2004; FAO and Worldbank, 2009; IAASTD, 2008 and see PBL, 2010). Also in South America improvements to reduce the yield gap can be made. Causes of yield gaps are manifold and include poor agricultural practises and management, unclear land tenure, poor logistics and transport possibilities and inadequate functioning of (agricultural) structures like R&D facilities and agricultural services (see PBL, 2010). The effects of apparent yield gaps are continuous land clearing on one side and production of fallow and unproductive land on the other side.

Cattle production and pasture expansion into the Amazon is seen as a paramount driver of deforestation. Comparing yields of cattle in Brazil with for example the USA, shows that Brazil meat yields are rather low (Figure 6), up to a factor of ~60%. Production circumstances are not easily comparable; many areas in the Amazon face low soil fertility. This low fertility is probably an important factor for low meat content. On the other hand, cattle densities in the studied case area along BR-163 do not differ largely from what is found in Europe (about 1.5-2 animals per ha). If local farmers would be able to increase meat content by improved farm practises, what would be the emission avoidance by reduced deforestation, given an equal amount of meat production? We can only speculate on this, but using different improvement rates of meat content the greenhouse gas emissions from deforestation could be reduced by a factor of 30% in the period between 1990 and 2009 in the case study area (Figure 7).

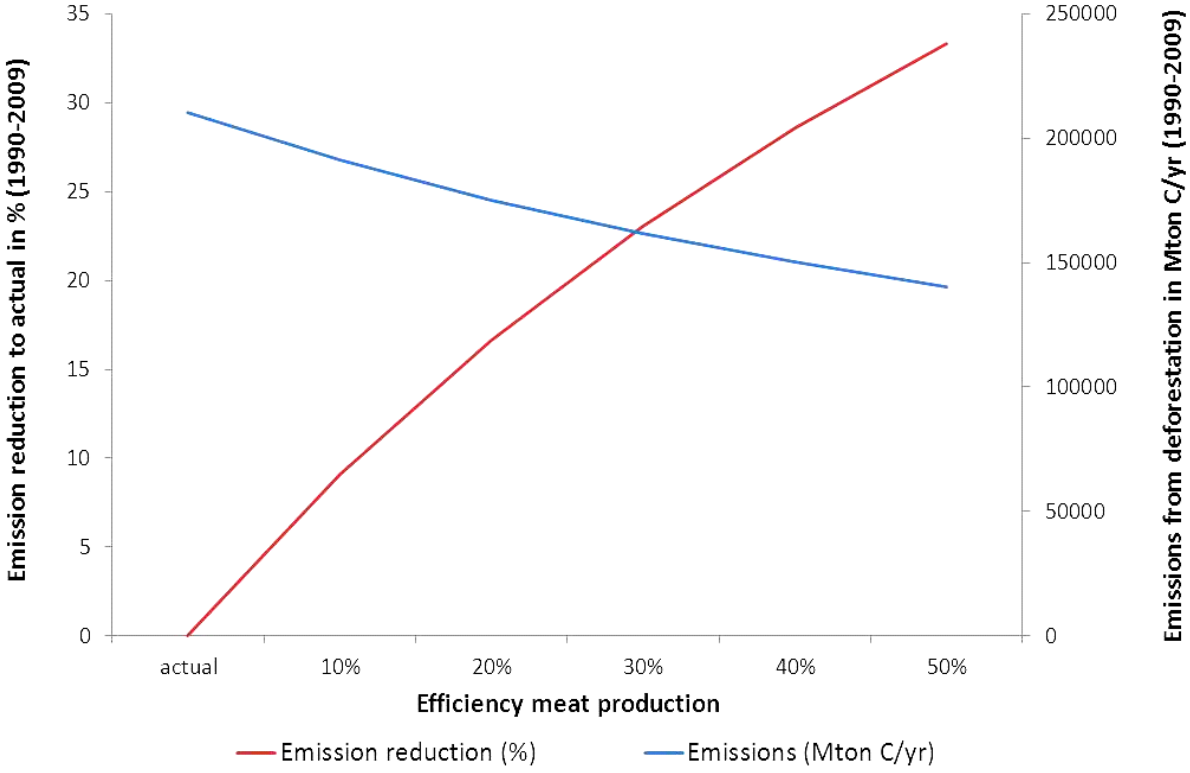

Figure 6: Comparison of meat content of cattle from USA and Brazil between 1990-2009. Data: FAO database.

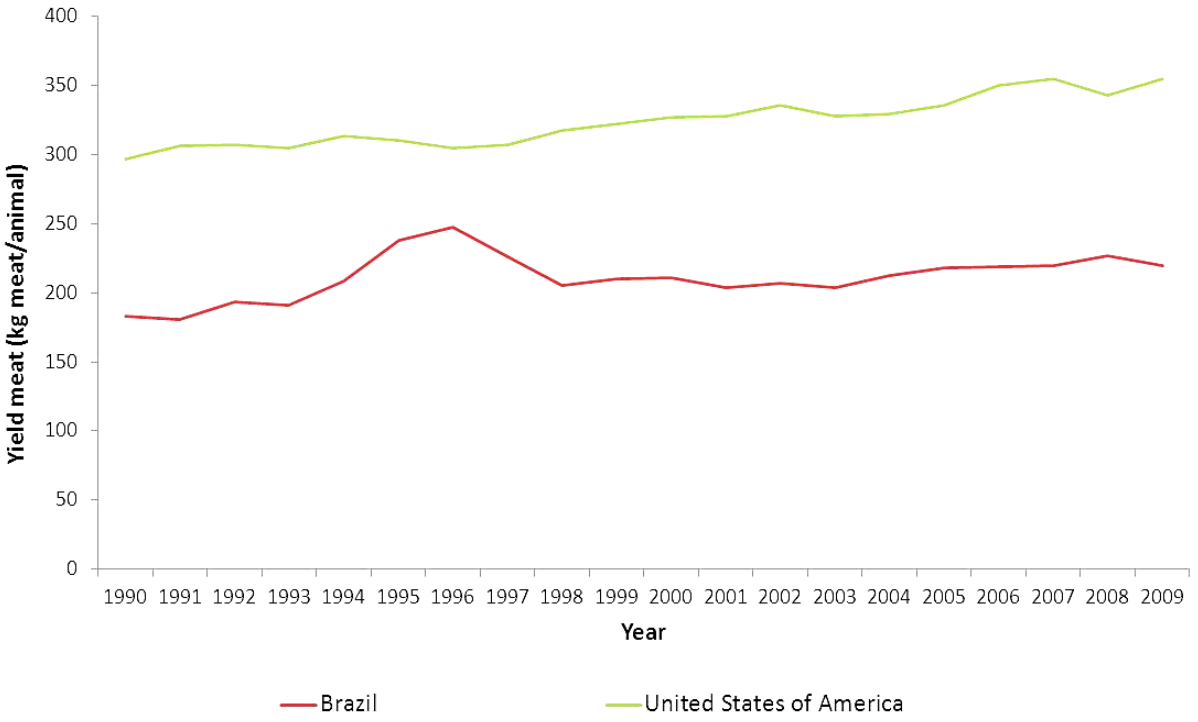

Figure 7: Calculations of emission reduction in the period between 1990 and 2009 in the case study area by assuming an increased meat content (10%, 20%, 30%, 40% and 50% increase compared to the actual situation) due to technological development. The total emissions from deforestation between 1990-2009 are given for the different scenario assumptions, including the actual values (blue line, right axis) and emission reduction as % difference from the actual situation (red line, left axis).

Although agricultural intensification requires less land with equal production, it does not mean deforestation will also be reduced. Several studies (e.g. Angelsen and Kaimowitz, 1999, Van Soest *et al.*, 2002, Kaimowitz and Angelsen, 2008, Angelsen, 2010) show deforestation might even increase with technological development. Underlying drivers of this additional deforestation are complex, but are related to improved farm income as such that labour will become available for additional deforestation (e.g. Carpentier *et al.*, 2000). Hence intensification policies need to be part of a larger policy framework with strong institutions to discourage additional clearing, otherwise intensification will only lead to accelerated deforestation.

Conservation policies lead to some extent to scarcity of potential agricultural land. Van Meijl *et al.* (2006) showed that with scarce land, land rental price will rise. Using a land-supply curve, Van Meijl *et al. (*2006) argued that a diverging pattern in the increase of agricultural production can be found. Regions with a large supply of area will increase production by adding agricultural land, while in regions with a lack of land this increase can only come from technological development. This latter pattern is found in densely populated areas like Europe; agricultural land has been stable for many decades while the production increases each year.

In Brazil, land is highly abundant and this is one of the reasons the country is one of the largest soy producers in the world. About 26% of all soy is produced in Brazil of which 49% in Mato Grosso, Mato Grosso do Sul and Goiás (e.g. Kamphuis, 2010). This large growth contributes strongly to the country GDP. Brazil can maintain this position of one of the largest soy exporters due to the fact that land remains abundant for the coming decades and land rights of natural areas are poorly defined. As a result the production factor of land is very cheap compared to the international context. It is also likely this same process hampers agricultural technological development to increase productivity. Such an increase would make soy more expensive due to substantial investment costs. That investments in agricultural productivity remain largely undone can be seen by examples of Embrapa (Brazilian Agricultural Research Corporation), which estimates around 20 to 50 million ha of degraded lands in Brazil, caused by overgrazing of cattle and lack of nitrogen inputs (see Wilkinson and Herrera, 2010a; Wilkinson and Herrera, 2010b). Although crop and cattle farmers are distinct land use types, intermingling them may favour grassland productivity, since soy production systems fixates nitrogen from the atmosphere. Finally, the policies that promote bio-fuel production within other Brazilian agricultural regions, especially ethanol, have ambiguous consequences with respect to climate: while they support the production of less polluting energy sources, alternatives to fossil fuels, the expansion of their production, as is currently occurring, if not regulated, may force the dislocation of livestock and other agricultural activities toward the Amazon (Rodrigues Filho, 2010). This will lead inevitably to a challenge for the role of the forest in the mitigation of climate change.

3.4 Linking productivity and mitigation targets

The National Policy on climate change provides quantitative mitigation targets for agriculture, ranking different strategies to be taken until 2020: recovery of 15 million hectares of degraded pasture, expansion of 4 million hectares of area that integrates agriculture-pasture-forestry,

increase of 8 million hectares of no-tillage agriculture and replacement of 5.5 million hectares in the use of nitrogen.

In this context, economic instruments that encourage conservation and intensification of production are possible and interesting pathways, such as payment for environmental services. Reduction of taxes may privilege the intensification of production. Combining with forest conservation these may translate into efficient mechanisms in the convergence between gain of environmental quality and economic development. Financial lines as the Climate Fund and Amazonian Fund are important mechanisms to overpass the aforementioned dilemma.

4 Conclusions

Since the land use sector is the largest emission source in Brazil, a transition towards a low carbon economy should be strained in efficient land use. On one hand, Brazil faces an ever increasing demand of agricultural bulk products, like beef and soy. It is not likely these demands decrease in the coming decades. Investments in agricultural techniques and practises are needed to increase productivity, while results also show large areas of degraded lands that should be cultivated again. Such actions comprise investments in agricultural techniques, while training and technical assistance of local farmers is needed. But intensification alone is no guarantee forest areas will be protected. Intensification can accelerate deforestation due to improved farm income as such that labour will become available for additional deforestation. Hence land use policies to reduce greenhouse emissions can only be effective where agricultural intensification is combined with economic instruments to discourage forest conversion to pastures, a sound monitoring system, surveillance, law enforcement and an adequate system of land tenure is at place to conserve natural areas.

Finally the role and importance of consumers should be highlighted in environmental governance. Most of the agribusiness production of the BR-163 has as final destiny to the southeast and south of Brazil, as also the European (e.g. the Netherlands and Great Britain) and Asian markets (e.g. China). The dilemma presented in this work is part of the responsibility of the Brazilian government, but is also maintained by the world commodities market fomented by countries that have no sufficient land to attend their demands. They rely on southern countries – abundant in natural resources – to maintain domestic consumption patterns. Such actors have a fundamental role to encourage more sustainable production chains. However, many governments, like those in the Netherlands, are reluctant to influence consumer behavior that provokes a less meat-rich diet. Hence the role of NGO's to change consumer behavior becomes paramount. Currently in the Netherlands a strong debate amended by NGO's is taken place for additional tax measures on meat consumption.

The establishment of the Round Table of Responsible Soy (RTRS) in 2006 (see Kamphuis et al., 2010) has become a first step towards a more sustainable production. Subsequently, international scientific cooperation should provide subsidies so that complex dynamics can be well comprehended and possibilities of action can be identified. However, the materialization of a more sustainable model will only be viable if the action is coordinated between actors in local, regional and international levels. Such dynamics in the Amazon transcend the regional and national frontiers achieving higher chains of relations in a global setting.

Acknowledgments

This study was part of the 6th framework project LUPIS (GOCE-036955) that run from February 2007 to March 2011 and was financially supported by the European Commission. We gratefully acknowledge the comments of two anonymous reviewers to improve an earlier version of this paper.

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