International Journal of Technology (2013) 1: 1-14
ISSN 2086-9614

LOOKING BACK – AN ANALYSIS OF THE DEVELOPMENT OF THE AGRICULTURAL PRODUCTION AND DEFORESTATION WORLDWIDE: AN ARTICLE ON THE CURRENT GLOBAL ILUC-DISCUSSION

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(Received: December 2012 / Revised: January 2013 / Accepted: January 2013)

ABSTRACT
ILUC is the abbreviation for Indirect Land Use Change. ILUC predictions mainly depend on the assumptions about how the additional agricultural demand for biomass production is covered. But iLUC due to agricultural growth varied strongly in the past among the different regions worldwide. Therefore, we analyzed the correlation between the development of the agricultural production and the land use changes and investigated which options (expansion of the agricultural area, increasing productivity, forest clearing etc.) supplied the feedstock demand for the growing agriculture sector in the past. Our investigations altogether show what the essential option for the increase of the biomass production has been and how it is related to the intensification of the usage of existing agricultural area, globally and even in countries with a high deforestation rate. Besides this the analysis of the main drivers of land use change in the past due to agriculture growth is essential for iLUC predictions and prevention policy. One driver was the loss of agricultural land in important areas all over the world. Our analysis shows that governance has a central influence on the development of land use. If the decoupling of production increase from the expansion of agricultural area for biomass production into nature areas wants to be achieved, it will have to happen via governance in the relevant countries. Therefore, instruments have to be developed and implemented that are able to regulate land use sophistically corresponding to the individual countries.

Keywords: Agricultural production; Biofuels; Deforestation; Governance; ILUC

1. INTRODUCTION

An analysis by the IPPC of 164 climate protection scenarios (see Figure 1) shows that the energetic use of biomass is of crucial importance to reach the climate protection goal of 2 degrees in 2050 (Edenhover et al., 2011).This is mainly the case, because biomass forms the most versatile of the renewable energies.

Table 1 illustrates that different renewable energy sources can provide electricity and thermal energy, whereas today, with few exceptions, only biomass can be used for power/mobility and chemistry. The study "Blueprint Germany", made on behalf of the WWF, sees the introduction of bio-energy as necessary in some transport sectors (road freight and aviation industry) to reach long-term climate protection goals, because of lack of alternatives (Öko, 2009). Even critics of the use of biofuels in the transport sector state that today there are no alternatives for the application of biomass, at least within some sections of the transport sector (aviation, shipping etc.). We have underlined the point, that Biomass is also essential for certain industries like the Metal-Industry and Chemical Industry.

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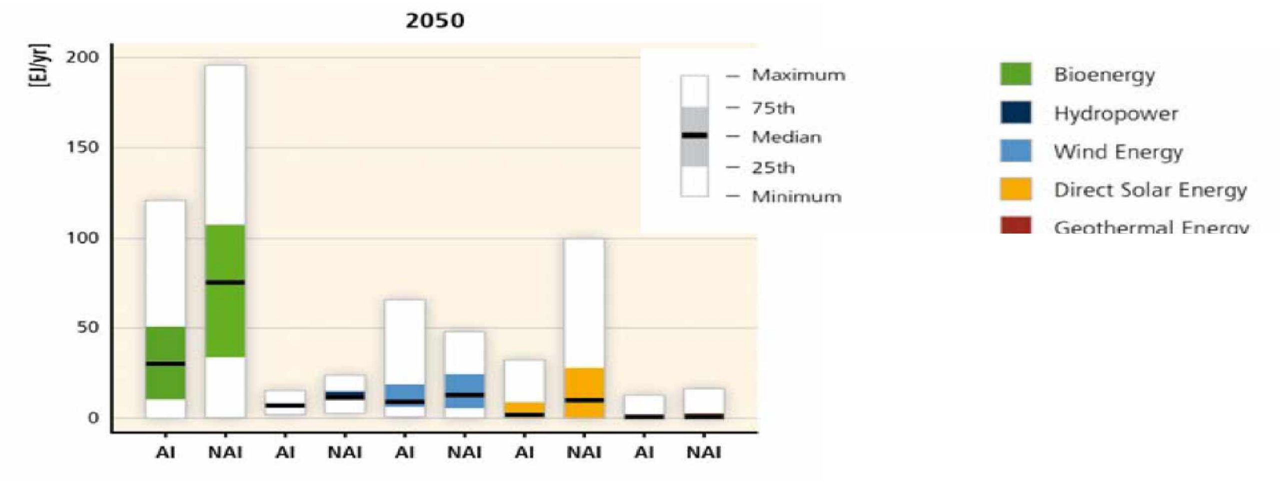

Figure 1 Meaning of the different renewable energy divisions within climate protection scenarios (Edenhover et al., 2011)

Table 1 Today's areas of use of renewable energies in different sectors

Useable Renewable E.	Heat/Cold	Electricity	Power/Mobility	Chemistry
Sunlight	+	+		
Wind		+	+	
Biomass	+	+	+	+
Waterpower		+	+	
Geothermal E.	+	+		

Bio-energy's, especially the biofuel's, contribution to climate protection, however, has been questioned by scientists in recent years (Searchinger et all., 2008; Laborde, 2011; Creutzig, 2012). The main point of the investigations' criticism is that the environmental balances (LCA) of biofuels do not incorporate the greenhouse gas effects of direct or indirect land use changes. These aspects can compensate or even exceed the greenhouse gas saving effects which are generated through the substitution of fossil fuels with biofuels. This means the application of biofuels would eventually lead to additional emissions. Direct land use changes can occur if grassland is plowed or forest is cleared in order to cultivate energy crops. Greenhouse gas emissions are generated that way, especially through the release of the carbon which is bound in soil and vegetation.

These could be indirect land use changes (iLUC) through use of bio-energy when the cultivation of energy crops in Germany displaces the previous crops, which then have to be replaced by import goods. This leads again to the expansion of agricultural area in other regions of the world at the expense of, for example, hitherto unused natural landscape.
Indonesia and Brazil are currently the countries which significantly contribute to land use changes. Nearly half of the tropical deforestation takes places in these two regions. According to the evaluation of various studies, forest clearing through iLUC occurs mainly in Indonesia and Brazil (Laborde, 2012; Marelli 2011). The most recent publications of the JRC (Marelli 2011) say that over 50% of the expected global iLUC effect in the course of the EU expansion goals for biofuels will be caused by land use changes in Indonesia (through forest clearing and the effect of draining of forest land on peat soils). Together with Brazil a share of 2/3 of the global iLUC emissions add up. The bigger part of the iLUC problem could be solved by good governance measures within these two regions. For this purpose not merely forest protection is

needed; to avoid a situation that the forest protection leads to another displacement of production to other regions, and intensification of the agricultural production on the existing agricultural area must also take place.

The IPCC sees the solution of the iLUC problem as well in the improvement of land use. In cases where increases in land use due to biomass production for bioenergy are accompanied by improvements in agricultural management (e.g., intensification of perennial crop and livestock production in degraded lands), undesirable iLUC effects can be avoided. If left unmanaged, conflicts can emerge. The overall performance of bioenergy production systems is therefore interlinked with management of land and water resources use. Trade-offs between those dimensions exist and need to be managed through appropriate strategies and decision making" (Edenhover et al., 2011).

In this context our publication analyses the correlation between the production of agricultural commodities and forest clearing in various regions worldwide from 1960 till 2010.The analysis examines the following questions:

- Is there a relation between forest clearing and the production of agricultural commodities?
- How does good governance (forest protection measures) influence the agricultural production?
- Which land use options (increase in yields, expansion of area etc.) have been chosen to satisfy the increasing agricultural demand?

2. METHODOLOGY

In recent years, many investigations have been performed to predict the developments of land use, with the aid of elaborate computer models. On this basis, political recommendations have been derived to regulate, *inter alia,* biofuels.

This work takes another path: Data of the past will be analysed. Here, the advantage is that one stands on more solid ground regarding the method. Conclusions which are important for the current discussion of the biomass issue can be also drawn from developments of the past.

2.1. Structure of the analysis

The analysis consists of the following stages

1. Correlation between the development of the agricultural production and the land use changes
2. Analysis of land use options for the increase of agricultural commodities

2.2. Regions for the analysis

The development of the agricultural production and land use changes in the USA, the EU, Brazil and Indonesia are examined. Table 2 shows the crops analysed and the production volume in 2010.

Moreover, the development of pasture land has been analysed.

2.3. Database

The analysis mainly deploys data of the FAO to display the development of production and the area of different agricultural goods (FAOSTAT, 2012). Although the quality of the FAOSTAT data is criticised by some studies, it is the only annually updated database that contains agricultural data of all countries worldwide, divided in crops and cultivation area (European Commission, 2010).

Table 2 Production volume of the crops analysed in 2010 (FAOSTAT, 2012)

Country	Product	Production (ton)		Production (ton)		Production (ton)
	Cereals		Oilcrops		Sugar cane	
Brazil	Maize	56.060.400	Soy			
	Rice	11.308.900				
	Wheat	6.036.790				
	Total	**75.731.026**		**13.436.839**		**719.157.000**
EU-27	Wheat	136.506.828	Rapeseed	20.384.267		
	Maize	57.795.277	Sunflower seed	6.910.516		
	Total	**281.634.306**		**13.903.197**		
Indonesia	Rice	66.411.500	Palm oil	21.534.000		
	Maize	18.364.400				
	Total	**84.775.900**		**26.977.326**		**26.500.000**
USA	Maize	316.165.000	Soy			
	Wheat	60.102.600				
	Rice	11.027.000				
	Total	**401.704.350**		**18.852.709**		**24.820.600**

The data about forest area are also based upon the FAO. Further sources had to be consulted, because the FAO started including data about forest area first in 1991 (FAO, 1993; U.S. Department of Agriculture, 2009; Feamside, 2005; Department of Agriculture, 2009; Department of Agriculture, 2011; FGI/GFW, 2002; Pacheco, 2002; Gold, 2003; Makiko, 2003). Next to primary data, also secondary data have been used for the analysis of land use options which increase agricultural production. The purpose of this is to illustrate the detailed choice of land use options in an exemplary way for a sub-region.

3. RESULTS

3.1. Correlation between the development of agricultural production and land use changes

The correlation will first be analyzed with the percentage changes of the development of agricultural production and land use between 1961 and 2009. The four subsequent figures show in which way the agricultural production and the land use changes have developed in the examined regions during the last 50 years.

Figure 2 analyses the development in the USA. During the last 50 years the agricultural production in the USA has increased by 150%, while the agricultural area for cereals and oil crops has only grown by 15 % and the area for forest and pasture has only changed slightly.

A look at the EU reveals similar conditions. Figure 3 displays that during the last 5 decades the agricultural production in the EU has increased nearly as heavily as it did in the USA. The agricultural area for cereals, oil crops and pasture land also remained almost constant, whereas the forest area even grew by 20%.

Figure 4 and Figure 5 illustrate that Brazil multiplied eightfold and Indonesia multiplied sixfold its agricultural production in the last 50 years, which is significantly more than the increase of the USA or the EU. At the same time the space for cereals, oil crops and sugar cane has tripled

(Brazil) or rather doubled (Indonesia), while the forest area heavily decreased. In this period of time the pasture land in Brazil grew by 60%; in Indonesia, it shrunk by 13%.

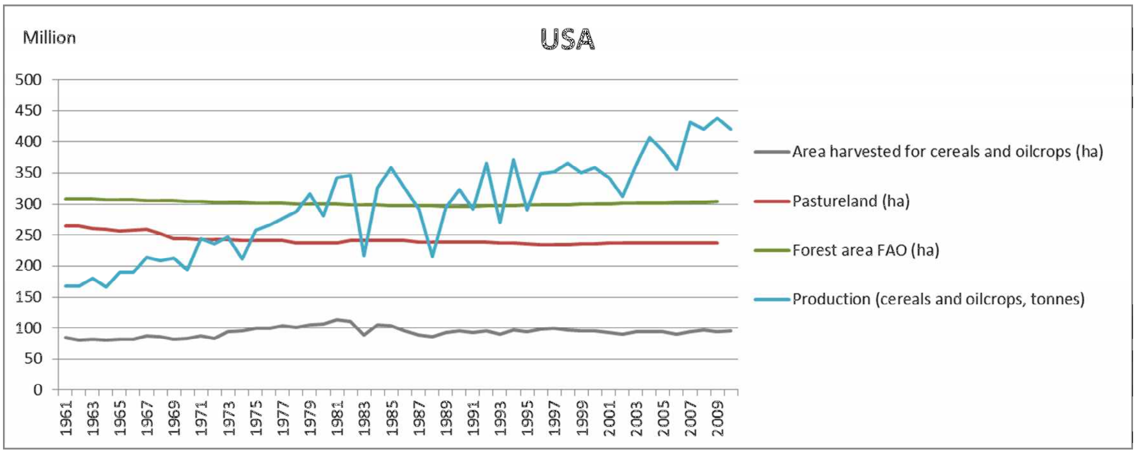

Figure 2 Development of agricultural production and land use changes in the USA

The analysis shown of the correlation between development of agricultural production and land use changes has led altogether to the following results (see Table 3):

- In all analysed regions the agricultural production has risen very strongly during the last 50 years: in the USA and the EU it has doubled, in Brazil it has multiplied eightfold and in Indonesia it has multiplied sixfold.

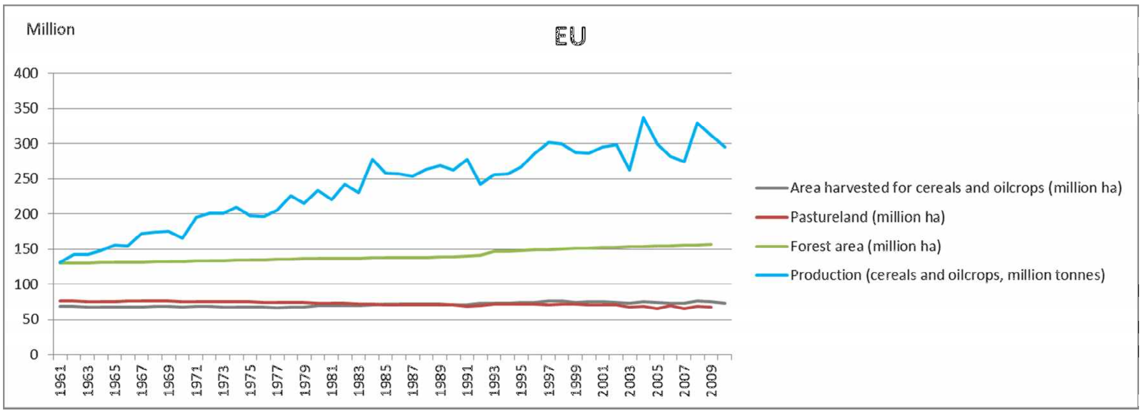

Figure 3 Development of agricultural production and land use changes in the EU

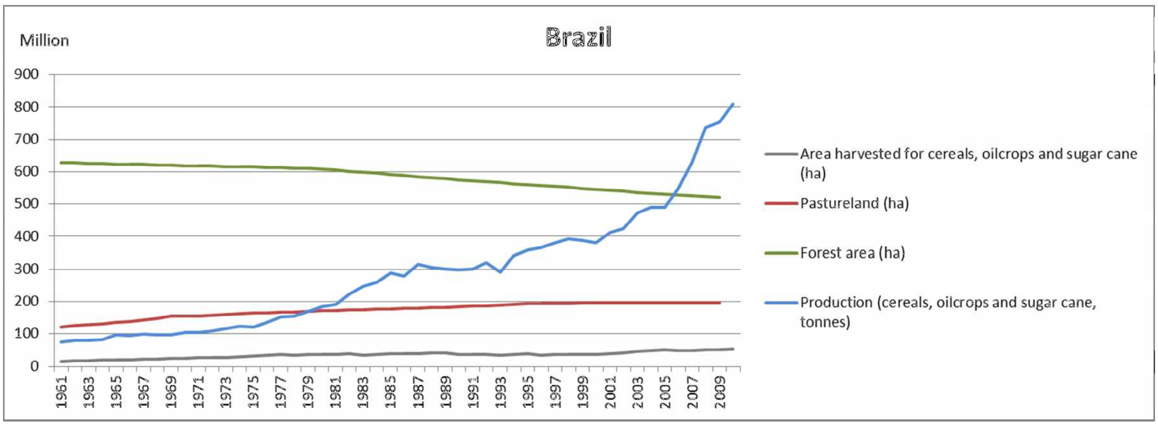

Figure 4 Development of agricultural production and land use changes in Brazil

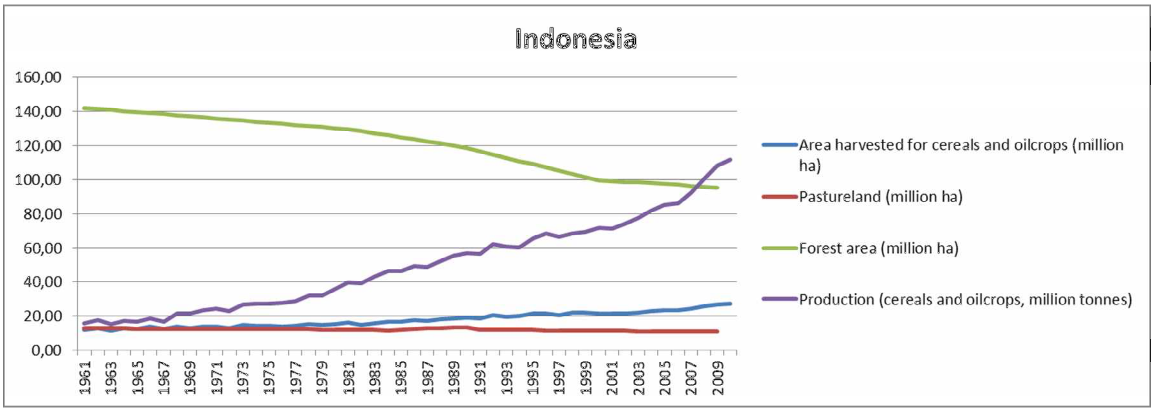

Figure 5 Development of agricultural production and land use changes in Indonesia

- The development of forest area is very diverse: in the USA it remained constant in the last decades or it rather even increased in the EU. In contrast to that, it strongly decreased in Brazil by 17% and Indonesia by 33%. There are similarities regarding the agricultural area: In the USA and the EU it has risen slightly, while it has tripled in Brazil and doubled in Indonesia.
- The pasture land in the USA, the EU and Indonesia decreased by approximately 10%, whereas it increased in Brazil by 60%.

Table 3 Changes of the agricultural production, forest area, agricultural area and yield per unit of area between 1961 and 2009 in the examined regions – changes in %

	Agricultural production	Forest area	Agricultural area	Pasture
USA	137%	-1%	15%	-10%
Europe	108%	20%	8%	-11%
Brasil	737%	-17%	189%	60%
Indonesia	512%	-33%	109%	-13%

For agricultural production and area the analysis compares the average value from 1961-1965 with the average value from 2006-2010.

Table 4 shows the statistical correlation between the agricultural production and the land use changes in the last 50 years. Some of the values correspond with the percentage changes presented above, like the statistical correlation between the agricultural production, the area harvested and the forest area in Brazil and Indonesia. But other results differ from the percentage changes, for example, the values for Europe. The statistical correlation between the agricultural production and area harvested is with r=0,89 as high as the value for Brazil. But the area harvested in Europe in the last 50 years only increased by 8% while it increased in Brazil by 189%. Therefore, the results of the statistical correlation have to be interpreted carefully. The r-value only shows how often the changes of two parameters occur simultaneously. But the r-value is not an indicator to describe if the percentage change of two parameters is similar during a period. So a high r-value of two parameters means that they are shifting simultaneously, but not necessarily with the same percentage change.

Table 4 Statistical correlation between the agricultural production and the land use changes between 1961 and 2009

	r-value between agricultural production and		
	Area harvested	Pasture land	Forest area (FAO)
USA	0,60	-0,75	-0,53
Europe	0,89	-0,86	0,88
Brazil	0,88	0,83	-0,96
Indonesia	0,99	-0,77	-0,98

3.2. Analysis of land use changes for the increase of agricultural production

The analysis of land use change options for the increase of agricultural production reflects the results of correlation analysis. In the USA and Europe almost exclusively the yield growth contributed to the increase of the agricultural production in the last 5 decades. In Brazil and Indonesia the situation is different. Although the yields in both countries increased by nearly 200%, the expansion of the agricultural area was also of great importance; in Brazil with 189% as important as the yield increases. On the one hand, the reasons for the differences are diverse legal conditions as described in chapter 3.1. On the other hand, in the past in Brazil and Indonesia the proportion of agricultural area to total territory was much smaller than in the USA and Europe (see Table 5).

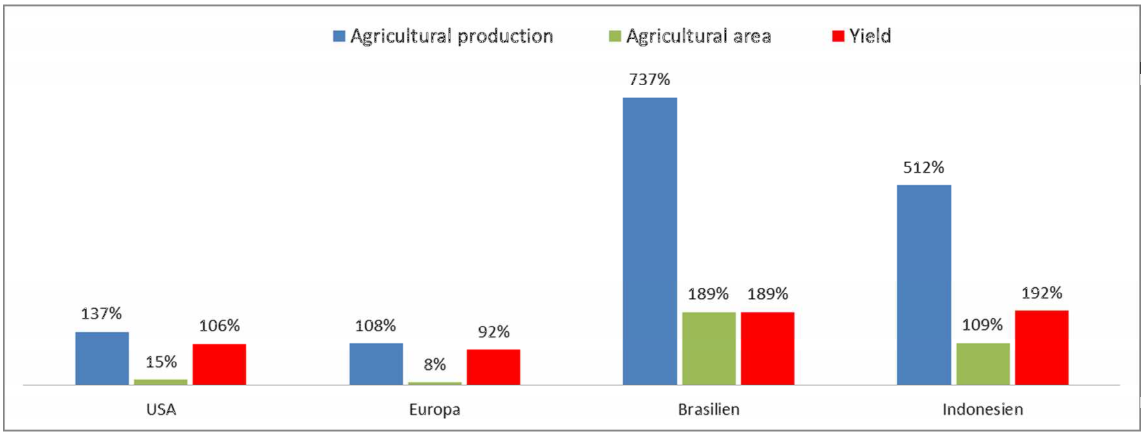

Figure 6 Comparison of agricultural area expansion, increase of production and yield increases

For agricultural production and area the analysis compares the average value from 1961-1965 with the average value from 2006-2010.

Table 5 Agricultural cultivation area in the analysed regions in 1961

	Agricultural cultivation area in million ha	Proportion of total national territory
USA	84	9%
Europe	69	16%
Brazil	16	2%
Indonesia	12	6%

The four following figures show the annual development of agricultural area, production and yield between 1961 and 2010. These figures underline the above mentioned results. And it is of interest, that during the below shown area expansion is not reflected in the world area for agricultural production. During this time period, the world agricultural area remained relatively constant from 1.52 to 1.53 billion hectares. The only possible explanation for this is a parallel loss of area for agricultural production in other regions in the world (e.g. in Africa).

4. DISCUSSION

On the basis of the FAO data it is not possible to make statements about which other usages (other crops, pasture land or forest) have been displaced through the expansion of the agricultural production. Because of the heavy reduction of forest area in Indonesia and Brazil, it can be assumed that the additional cultivation area has been mainly generated through forest clearing. H.K. Gibbs, A.S. Ruesch, F. Achard, M.K. Clayton, P. Holmgren, N. Ramankutty, and J.A. Foley, came to the same conclusion in the context of their analysis of the expansion of agricultural area between 1980 and 2000 in tropical areas (Gibbs et al.,2010). However, if further sources are consulted, this image will change for the last decade. The comparison between annual numbers of forest clearing (Figure 11) and the development of agricultural production in Brazil illustrates that since 2006 the deforestation has decoupled from production development. Figure 9 already gave some evidence for that development and showed that after 2005 yield growth contributed to the increase of the agricultural production instead of agricultural land expansion. The statistical correlation between the agricultural production and the annual numbers of forest clearing is with r=-0,41, significantly lower than the correlation between the agricultural production and forest area with FAO-Data (r=-0,96).

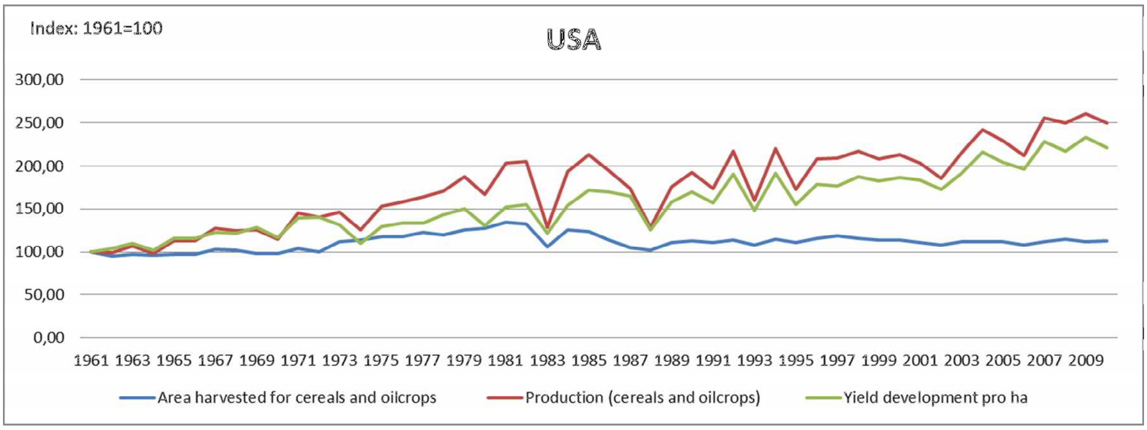

Figure 7 Annual development of agricultural area, production and yield in the USA 1961-2010

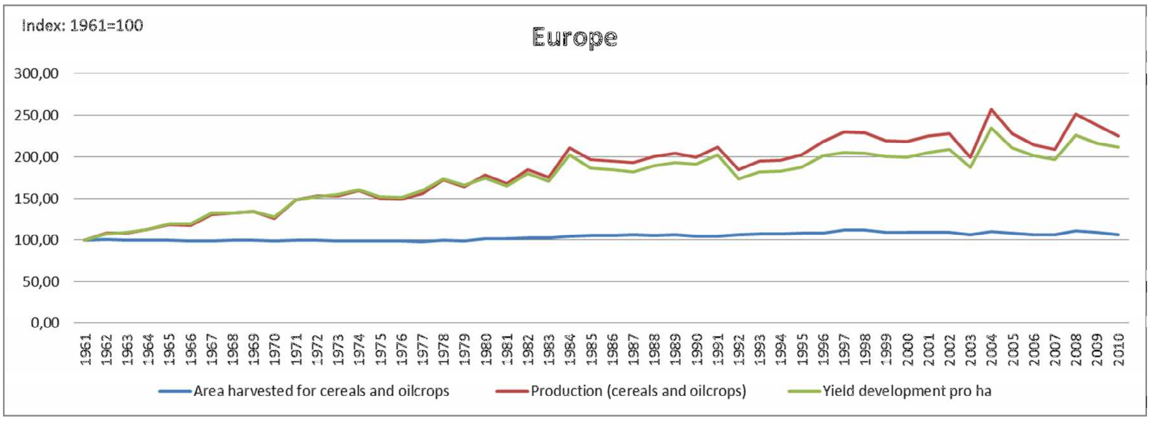

Figure 8 Annual development of agricultural area, production and yield in Europe 1961-2010

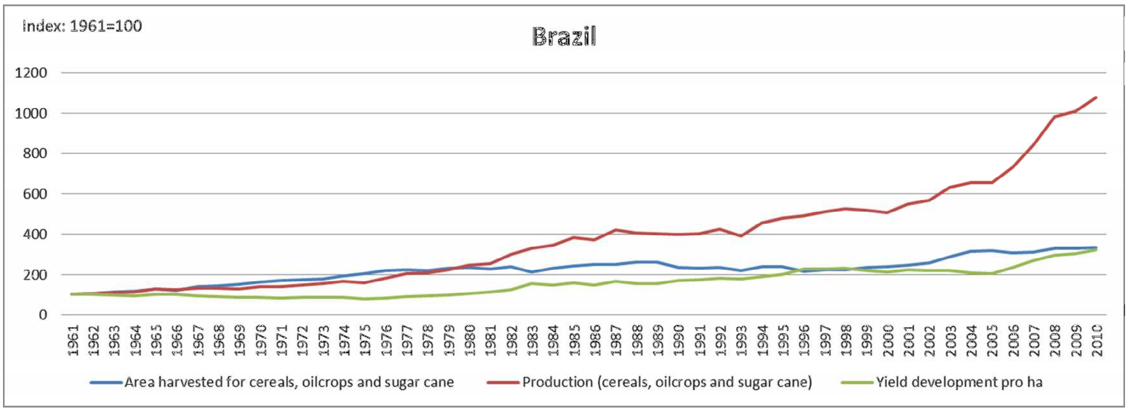

Figure 9 Annual development of agricultural area, production and yield in Brazil 1961-2010

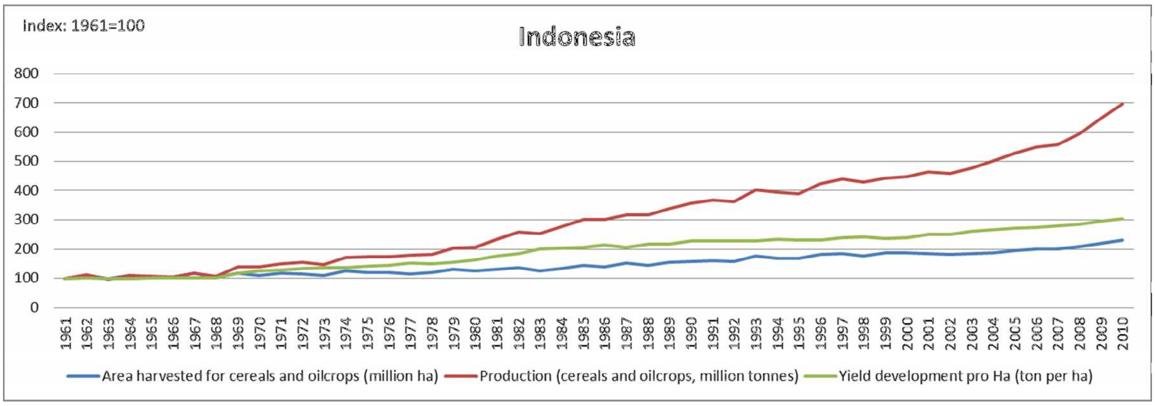

Figure 10 Annual development of agricultural area, production and yield in Indonesia 1961-2010

Figure 12 also illustrates the strong decline in proportion of forest clearing for the increase of soy production in the Amazon region (Macedoa et al, 2012]. Yield increases have instead contributed to the satisfaction of the additional demand. This shows that aside from the demand of agricultural goods, further parameters determine the land use changes.

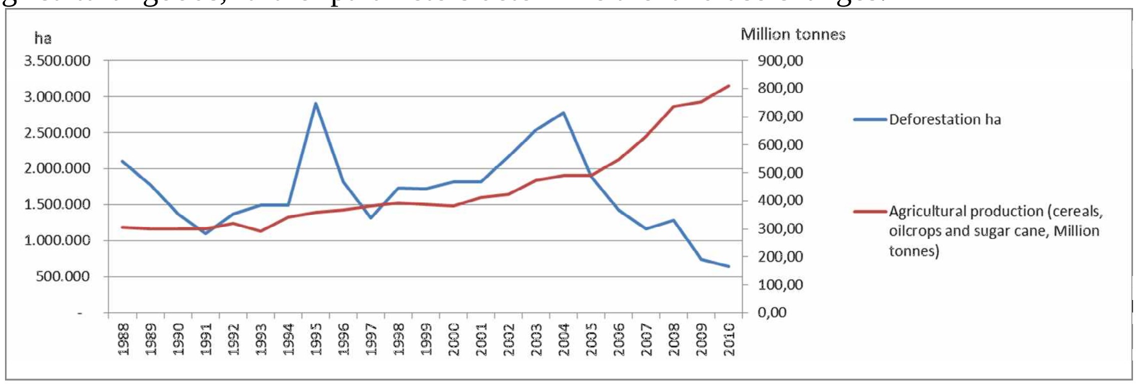

Figure 11 Annual numbers of deforestation and production development of cereals, oil crops and sugar cane in Brazil (INPE, 2012; FAOSTAT, 2012)

The multiple causes of land use changes in the tropics are described by H. J. Geist and E. F. Lambin, who evaluated 157 regional studies (Geist & Lambin, 2002). According to them, the deforestation of tropical rainforest is never the result of one cause, but the interaction of many elements. The investigation of the land use changes of 1966 till 2006 in Costa Rica by Armond T. Joyce confirms these results (Joyce, 2006). According to Joyce, at least 14 criteria are affecting the land use in Costa Rica.

The LUC analysis in MatoGrosso did also incorporate leakage effects. It found out that the decreased deforestation in MatoGrosso did not lead to an increase of forest clearing in its adjacent federal states. This shows that the cultivation of soy on pasture land did not lead to a displacement of pasture land into the rainforest. The cultivation of soy on pastureland did not reduce the animal husbandry as well. In fact, the number of cattle has continued to rise. The animal husbandry was intensified on existing pasture ground. The potential of the intensification of animal husbandry in the tropics is very high, because of the current pasture land's low per-hectare intensity (WWF, ECOFYS & OMA, 2011). In Brazil, for example, it averages 1 livestock unit per hectare, although it could be increased up to more than 6 livestock units (Nepstad et al, 2008). An intensification of land use is also possible in Indonesia. According to the Greenpeace study "Protection Money", it is possible to double the production of palm oil in Indonesia without the need of any additional space. Productivity potentials through the regeneration of degraded areas add to that. Investigations of the Utrecht University and the WWF reached similar conclusions (Fairhurst & Mclaughin, 2009; Wicke et al., 2008).

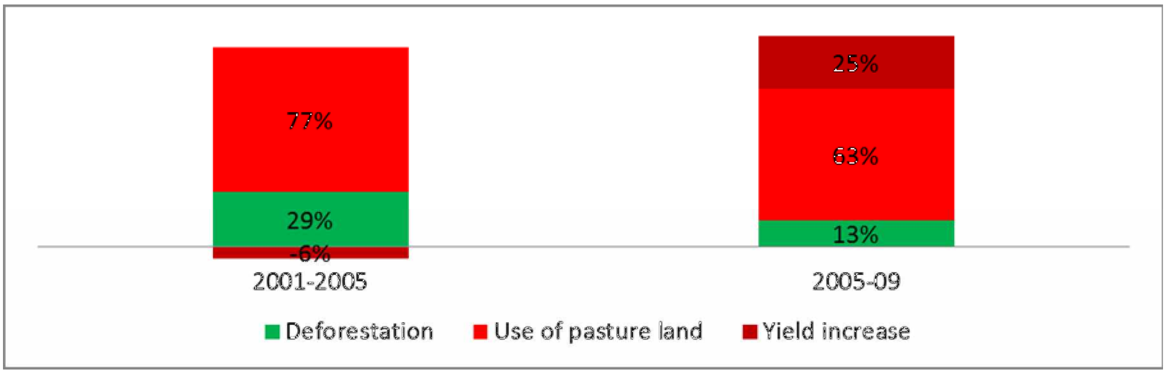

Figure 12 Choice of land use options for soy in MatoGrosso (2001-2009) (Macedoa et al., 2012)

The investigations above altogether show that the essential formation option for the increase of production has been and is the intensification of the usage of existing agricultural area, even in countries with a high deforestation rate. Here, it becomes obvious of how important the intensification of land use can be, because the tropic countries in particular are far from fully utilising these potentials. Consequently, it becomes clear that the governments have some elbowroom within their arrangement of land use options. For the purpose of an increase in production, land use intensification is a real alternative to deforestation.

And as also analysed above, the governments have the chance, reducing the losses of agricultural land and even winning back some of the lost areas, to increase the production area without harming rainforest and other natural habitats.

The analysis of the agricultural history which was used here shows that the production increase of agricultural commodities is not compulsively accompanied by deforestation. Further criteria, especially political framework conditions, have strongly influenced this process. For that reason it is someway impressive, governance is a neglected parameter in the current discussion of, for example, the pro and cons of biofuels.

The analysis of the past indeed shows that governance has a central influence on the development of land use (Miranda & Mattos, 1992; Volpi, 2007; WWF, ECOFSY & OMA, 2011). The analysis of the more recent past also shows that the influences on the land use changes are not structured in a simple and mono-causal way; they show that there have not been any convincing investigations yet that scientifically apprehend the structure of these influences.

One possible reason is that a global research approach will probably fail, as cultural and country-specific framework conditions are too diverse.

Here, we arrive at the conclusion that probably the crucial research deficit is present in this field: to understand, how to regulate the agricultural development in the biomass sector positively in terms of the climate protection, using regional governance. And at this point it is worth to mention, what governments have already decided e.g. in Malaysia and Indonesia to protect their habitats. Would they implement their decision, the iLUC-Situation would change completely. This question is not even part of iLUC-modelling!

5. CONCLUSION

Is iLUC real? Yes, it is. But our calculation and analysis show, that it is a policy driven phenomenon. It shows also, that the loss of agricultural area is in the scientific discussion about iLUC an up to now a neglected factor.

In the EU there is currently a controversy about the way to include the iLUC phenomenon in the biofuel legislation. The Climate Directorate-General (DG) and the Environment DG of the European Commission favour so-called iLUC factors, which are factored as flat-rate and global parameters into the calculation of greenhouse gas savings of the particular biofuel as a penalty. This means that the savings of greenhouse gas through biofuels would be reduced via calculation. In this way, greenhouse gas reduction through biofuels should be reached despite iLUC. In our opinion it is a wrong way.

If the decoupling of production increase from the expansion of agricultural area for biomass production into nature areas wants to be achieved, it will have to happen via governance in the relevant countries. Therefore, instruments have to be utilised that are able to regulate sophistically corresponding to the individual countries.

The analysis of the agricultural history shows that this decoupling was and is possible and has already been achieved in many countries.

With the biofuel legislation, the Europeans create an artificial market and grant biofuel producers advantages through the compulsory rate of biofuels. These advantages are the starting point for a country-specific and WTO-compatible instrumentation of an iLUC regulation, because Europe is not forced to hand on the quota advantage to biofuel of every origin, i.e. every producing country. If in any country, the biofuels show no or too small a climate protection effect, because of iLUC or lacking good governance, it will be possible and obligatory to deny the eligibility on the quota in Europe.

What would happen if the decision would be made that palm oil from Indonesia is not acceptable for Europe’s biofuel sector? One could argue that the Indonesian government would not care, because the majority of their palm oil is exported to China or is used for the production of food or chemicals. But would the food industry keep using a commodity which is - put slightly exaggerated - not even worthy of combustion? - Probably not. The phasing-out of a commodity from one single country, of course well justified, would be a very strong signal, which would trigger instant and fundamental change in this country towards decoupling of agricultural production from the conversion of natural areas. And in Indonesia the government is in the comfortable situation, having already decided, to protect their remaining forests and peatlands and only have to enforce this decision.

Aside from increase in yields, the decoupling can also be achieved through the usage of disused land and the recovery of degraded areas. Here as well, there is plenty of potential. According to FAO data, 3.5 billion hectares of space are currently degraded worldwide (Metzger & Huettermann, 2008). That is 40% of the agricultural, pasture and forest area. So this explains that despite the described huge expansions in e.g. Indonesia or Brazil, the overall agricultural area has not expanded in the past decades. What chance is there to fight for iLUC?

Consequently, the governments in industry and developing have two powerful options to satisfy the growing agricultural markets, without converting or destroying carbon-containing natural areas. The analysis of the past times shows that the usage of these potentials is not illusory at all. On the contrary, the developments of the past decades illustrate that the higher land use efficiency of the production was by far the most important factor for the production increase.

The better understanding of how governance in the different countries is able to cause or to effect change in these developments is what is unfortunately missing up to the present day; the analysis of the past is only of limited help here. In this context, it seems astonishing how many investigations are available that try to forecast iLUC mathematically and how few analyses there are that attempt to understand iLUC in a social and political way. It is a widespread error to believe, that land use changes are simply an agro-economical phenomenon.

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