Competing claims on land for food and biodiversity

LEI WAGENINGEN UR

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Contents

	Preface		**7**
	Summary		**9**
	S.1	Key results	9
	S.2	Complementary results	9
	S.3	Approach and background	11
	Samenvatting		**12**
	S.1	Belangrijkste uitkomsten	12
	S.2	Overige uitkomsten	13
	S.3	Benadering en achtergrond	14
1	**Introduction and approach**		**15**
2	**Key features of the agrifood sector in Brazil, Central Africa and Indonesia**		**16**
3	**Scenarios and scenario implementation**		**18**
4	**Key results from the Baseline scenario**		**21**
5	**Impact of intervention measures on land, production, consumption and trade**		**24**
	5.1	Impact on competing land claims	24
	5.2	Impacts on production, consumption and trade	24
6	**Price and income effects with impacts on food security**		**30**
7	**Conclusions from global model projections**		**33**
8	**Developments in Brazil**		**34**
	8.1	Model projection outcomes for Brazil	34
	8.2	Land dynamics	34
	8.3	Land protection	37
	8.4	Increased agricultural productivity	39
	8.5	Sustainability	42

9 Case Central Africa: likelihoods of scenario assumptions and results 44
9.1 TEEB analysis 44
9.2 Land dynamics in Central Africa 45
9.3 Land protection - conservation of biodiversity 45
9.4 Increased agricultural productivity 48
9.5 Reduced losses in food chain 51

10 Competing claims in Indonesia: palm oil and alternative crops 52
10.1 Global and national drivers 52
10.2 Palm oil 53
10.3 Drivers for land use change 54
10.4 Alternative crops: jatropha hype cycle 56

11 Major findings and concluding remarks 62
11.1 Major findings 62
11.2 Concluding remarks 63

Literature and websites 65

Appendix
1 Areas suitable for agriculture 77

Preface

By 2050 the world population is expected to grow to 9bn people. In combination with increasing wealth and changes in diets and consumption patterns this will result in strongly increasing demands for food, fibres and energy. In this context an important challenge for the next decades will be how to sustainably supply enough food given limited area of available land and natural resources. These resources are often not equally distributed. Changes in land use and extension or intensification of agricultural land may lead to economic and social tensions and increase pressure on biodiversity and other services ecosystems provide.

This report is part of the BO Competing claims project that aims to increase the understanding of processes governing competitive land use, to elaborate the factors that play a determining role, and to assess options for sustainable use of natural resources in different contexts. The project aims to contribute to EL&I's knowledge base necessary to apply the policy principles drafted in the ministry's Policy note on food security (2008) and directly addresses issues that relate to the UN Millennium Development Goals, the Convention of Biological Diversity, the Convention of Sustainable Development (CSD 17) and The Hague conference on agriculture, food security and climate change (October/November 2010).

In this report the authors address consequences of biodiversity conservation targets for food security at a global level and reflect on the outcomes by looking into specific local situations in Brazil, Central Africa and Indonesia. The local processes governing competitive land use are often more complex than present global models are able to include. Solutions to reduce the pressure on biodiversity rich areas like increasing productivity require an integrated approach in which interventions linked to agro-ecological, economic and institutional factors should be considered simultaneously.

This EL&I assignment has been elaborated by a Wageningen UR team including researchers from different disciplines from Alterra, LEI, ISRIC and PRI. More project results are available in the LEI and Alterra series of reports.

Prof Dr R.B.M. Huirne
Managing Director LEI

Summary

S.1 Key results

Biodiversity losses can be reduced and food security improved by applying measures to increase yields and reduce food losses.

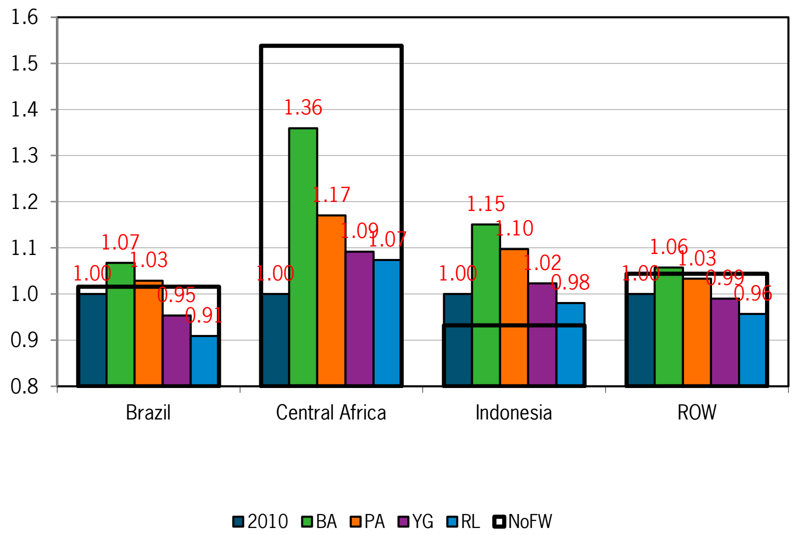
World demand for agricultural commodities will increase to meet welfare and population growth. This will lead to increased demands for agricultural land and in a loss of biodiversity. Our model simulations demonstrate that biodiversity losses can be reduced by applying measures to protect ecologically vulnerable areas, increase yields and reduce food losses, with the effect of improved food security in all countries or regions analysed. Case studies show, however, that the potential to increase agricultural land productivity varies significantly among countries, while options to protect ecosystems with high biodiversity depend greatly on political and economic forces.

S.2 Complementary results

The initiative to protect high bio-diverse areas through the Amazon Moratorium for soybean production and strict criteria for credit facilities for public and private investments in those areas seem to have retarded the pace of deforestation in Brazil (see section 8.3). Next, the perspective of further increase of agricultural production and yields in Brazil are promising, reducing the pressure on biodiversity rich areas to be used for agricultural purposes (see section 8.4).

In Central Africa options to increase productivity are limited by water shortage, soil degradation and frequency of drought (see section 9.4). Potential effects of reducing losses in the food chain are challenged because these chains are characterised by many intermediaries, poor infrastructure and market information (see section 9.5).

Figure S.1 **Agricultural land use development from 2010-2030 and the non-forest and woody land area (NoFW) suitable for agriculture a) b)**



a) The NoFW area cap reflects the area that is defined as area suitable for agricultural production that does not include forest and woody land. If the column is higher than the capped area (horizontal) line, the expansion of agriculture is only possible with pulling forest or wood land into agricultural land (See Appendix 1, for an extended Figure); b) agricultural land use in 2010=1.

In Indonesia, rapid expansion of palm oil production on previously forest covered area took place in the last two decades. It is unlikely that anything other than a significant drop in global palm oil prices and/or demand will derail the current trend in Indonesia, as possible suggested impediments such as a moratorium on forest clearing and timber extraction or a revocation of outstanding palm plantation development licenses have not been materialised (see section 10.3). Alternative crops - like jatropha, a potentially valuable biofuel crop - are not commercially interesting yet (see section 10.4).

Increasing production in areas with a serious productivity gap needs an integrated approach in which interventions linked to agro-ecological, economic and institutional factors should be considered simultaneously (see section 11.2).

The solution to the global problem of feeding the world in a sustainable way lies in local development, where obstacles towards increasing productivity should be removed and competing claims on natural resources be tackled. Aggregate measures on deforestation and human activities require coordination at governmental level, while the international community should create conditions to prevent undesired developments (see section 11.2).

S.3 Approach and background

Will the world be able to sustainably supply enough food given the expected increase in world population and wealth in the coming decades? This report examines land use, production, consumption, trade, income and food security effects of four future scenarios: a baseline scenario and three policy scenarios. The study models the implications of measures to limit agricultural land expansion and biodiversity loss while maintaining food security; the focus is on Brazil, Indonesia and Central Africa. The first two countries are important food producers, where increased agricultural activities, including expansion into high biodiversity areas have been reported, while Central Africa is a food importer who could suffer from increasing food prices. The study combines model simulation with a case study approach.

Samenvatting

S.1 Belangrijkste uitkomsten

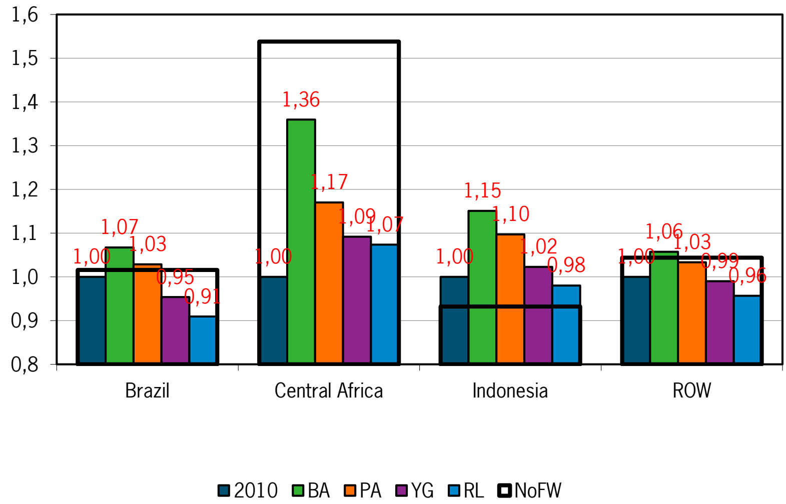
Het verlies van biodiversiteit kan worden gereduceerd en de voedselveiligheid kan worden verbeterd door maatregelen toe te passen om de opbrengst te verhogen en het verlies van voedsel te beperken.

De wereldwijde vraag naar landbouwproducten zal toenemen om aan de grotere vraag als gevolg van meer welvaart en de bevolkingsgroei te kunnen blijven voldoen. Dit zal leiden tot meer vraag naar landbouwgrond en een verlies van biodiversiteit. Middels onze modelsimulaties kunnen we aantonen dat het verlies in biodiversiteit kan worden beperkt door maatregelen toe te passen om ecologisch kwetsbare gebieden te beschermen, de opbrengst te verhogen en de voedselverliezen te reduceren, met een betere voedselveiligheid in alle geanalyseerde landen/regio's tot gevolg. Uit casestudy's blijkt echter dat de mogelijkheid om de productiviteit van landbouwgrond te verhogen significant varieert per land, terwijl de mogelijkheden om biodiverse ecosystemen te beschermen sterk afhankelijk zijn van de politieke en economische krachten.

S.2 Overige uitkomsten

Het initiatief om gebieden met een hoge biodiversiteit te beschermen via het Amazone Moratorium, waarin strikte criteria worden gehanteerd voor de productie van sojabonen en het verstrekken van kredieten voor publieke en private investeringen in deze gebieden, lijkt de ontbossing in Brazilië te hebben vertraagd. De vooruitzichten voor een verdere toename van de landbouwproductie door middel van groei van de productie per hectare in Brazilië zijn veelbelovend, waardoor de druk om gebieden met een hoge biodiversiteit te gebruiken voor landbouwdoeleinden afneemt.

Figuur S.1	Ontwikkeling van het gebruik van landbouwgrond van 2010-2030 en de beboste en niet-beboste grond (BnB) die geschikt is voor landbouw a) b)



a) De bovengrens voor BnB-grond vertegenwoordigt het gebied dat is gedefinieerd als gebied dat geschikt is voor landbouwproductie, exclusief beboste grond. Als de staafbalk hoger is dan de bovengrens (horizontale lijn), is het uitbreiden van de landbouw alleen mogelijk door van bosgrond landbouwgrond te maken; b) gebruik van landbouwgrond in 2010=1.

In Midden-Afrika zijn de mogelijkheden om de productiviteit te verhogen beperkt door watertekort, bodemdegradatie en de droogtefrequentie. Het is de vraag of reductie van verliezen in de voedselketen mogelijk is omdat deze ketens worden gekenmerkt door veel tussenpersonen, een slechte infrastructuur en beperkte informatie over de markt.

In Indonesië is de productie van palmolie op ontboste grond de afgelopen twee decennia in snel tempo toegenomen. Het is onwaarschijnlijk dat de huidige trend in Indonesië zal worden tegengehouden door iets anders dan een sterke wereldwijde daling in de prijzen van en/of de vraag naar palmolie, aangezien mogelijkheden om verdere voortzetting te verhinderen, zoals een moratorium op ontbossing en houtkap of een herroeping van verleende vergunningen voor het ontwikkelen van palmplantages, nog niet zijn verwezenlijkt. Alternatieve gewassen – zoals jatropha, een mogelijk zeer waardevol biobrandstofgewas – zijn op dit moment commercieel nog niet interessant.

Het verhogen van de productie in gebieden waar de productie per hectare sterk achterblijft bij wat agronomisch gezien mogelijk moet zijn, vereist een geïntegreerde aanpak, waarbij gelijktijdige interventies die gekoppeld zijn aan agro-ecologische, economische en institutionele factoren moeten worden overwogen.

Een duurzame oplossing voor het wereldwijde voedselprobleem ligt in lokale ontwikkeling, waarbij obstakels voor productiviteitsgroei moeten worden geëlimineerd en andere activiteiten die een claim leggen op natuurlijke bronnen moeten worden aangepakt. Maatregelen tegen ontbossing en activiteiten in ecologisch kwetsbare gebieden vereisen coördinatie van overheidswege, terwijl de internationale gemeenschap de randvoorwaarden moet creëren om ongewenste ontwikkelingen te voorkomen.

S.3 Benadering en achtergrond

Zal de wereld erin slagen op een duurzame manier voldoende voedsel te leveren op basis van de verwachte toename van de wereldbevolking en wereldwijde welvaart in de komende decennia? In dit rapport wordt onderzoek gedaan naar de effecten van landgebruik, productie, consumptie, handel, inkomsten en voedselveiligheid binnen vier toekomstscenario's: één baselinescenario en drie beleidsscenario's. Er wordt in kaart gebracht wat de implicaties zijn van de maatregelen om de uitbreiding van landbouwgrond en het verlies van biodiversiteit te beperken en de voedselveiligheid te garanderen. De focus ligt op Brazilië, Indonesië en Midden-Afrika. De eerste twee landen zijn belangrijke voedselproducenten waar een verhoogde landbouwactiviteit is gerapporteerd, inclusief uitbreiding naar gebieden met een hoge biodiversiteit. Midden-Afrika is een voedselimporteur die te lijden kan hebben van hogere voedselprijzen. Bij de studie wordt gebruikgemaakt van modelsimulatie en een casestudybenadering.

1 Introduction and approach

In a contribution to the UNEP project on The Economics of Ecosystems and Biodiversity (TEEB) assessment, Ten Brink et al. (2010) has quantitatively analysed a number of sector-based options to reduce global loss of biodiversity. Although biodiversity is the main impact variable that is assessed, the scenario options are built around a number of strategies that have a direct and broad link to land use worldwide and follow lines of reasoning that strongly match international policy strategies towards sustainable development. The scenarios are defined to account for issues and measures regarding the setting of priorities in conservation, reduced agricultural expansion, and reduced overexploitation of habitats and/or limiting climate change, resulting in eight options for reducing global biodiversity loss.

Most of these options will eventually have strong effects on land use and food security. Food security is assessed in the analyses as a combination of availability of food, the impact on prices, and the ultimate economic ability of households to acquire food.

This study evaluates the impact of measures that simultaneously reduce biodiversity losses without adversely impacting food security. In addition to a global assessment, we include a regional evaluation of the assessed impacts and reflect on current and predicted developments at country level, using insights into local conditions and circumstances. We have selected three regions, namely, Brazil, Central Africa[1] and Indonesia, which will be used to analyse local trends and drivers leading to competing claims. These regions were selected as many report increased agricultural activities, including expansion into high biodiversity areas (Gibbs et al., 2010) and predicted trade-offs between food, fuel and ecosystem services are expected to be particularly critical. Model simulations are conducted by using LEITAP, a multi-regional, static, applied general equilibrium model based on neo-classical microeconomic theory (Nowicki et al., 2007). The scenarios and their outcomes are reported in sections 3 to 7. Reflections on the findings of the model simulations are in section 8 (Brazil), 9 (Central Africa) and 10 (Indonesia). Section 11 concludes.

[1] Central Africa includes the following countries: Uganda, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Mayotte, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Sudan, Togo.

2 Key features of the agrifood sector in Brazil, Central Africa and Indonesia

Agriculture is an important economic sector in Brazil, Central Africa and Indonesia (Table 2.1). The share of agrifood in the total value of output in these regions is several times higher than the world average. In Central Africa and Indonesia, the value added share of the sector in the total value added is respectively about 4 and 3 times higher than the world average, while the share of incomes earned (wage bill) in the agrifood sector in these two regions are even greater than the world average. A significant share of agrifood production is exported by Brazil and Indonesia, where Brazil has exceptionally high per capita exports. Both of these countries have much land that could be used for agricultural purposes. While these countries thus have a strong possibility to expand their agricultural production area, this comes at the expense of forests, woody land and savanna that are considered to be rich in biodiversity. While expansion of agricultural production is likely to provide significant economic gains to these countries it also incurs a significant ecological cost to the global community. This is the key issue when it comes to governing national and international choice due to apparently unavoidable trade-offs.

Table 2.1	**Selected characteristics of agrifood sector in Brazil, Central Africa, Indonesia and World in 2010 a)**			
	Brazil	**Central Africa**	**Indonesia**	**World**
Share of agrifood sector in total value of output (%)	12	30	18	8
Share of agrifood sector in total value of added (%)	7	25	18	6
Share of agrifood sector wage bill in total wage bill (%)	4	35	20	5
Agrifood sector exports-production ratio (%)	16	8	13	9
Agrifood sector net-exports per capita (million, in constant 2001 $)	71	-1	17	-37
Share of agricultural land used in total available agricultural land (%)	35	59	49	59
Share of agricultural land used in total available agricultural excluded forest and woody land (%)	98	65	107	96

a) The 2010 figures were simulated using the 2001 GTAP database. The model simulation encompasses macroeconomic and policy variables updates up to 2010 (for further explanation, see Appendix 1: Database).
Source: GTAP data base and own calculations.

3 Scenarios and scenario implementation

This report examines land use, production, consumption, trade, income and food security effects of four future scenarios: a baseline scenario and three policy scenarios. The *Baseline* scenario[1] (BA) assumes the macroeconomic development as used by the USDA (2010) in agricultural projections up to 2030 (Table 3.1). The USDA takes into account the 2008-2009 economic recession and assumes a subsequent recovery followed by a return to the long-term steady global economic growth path. The world GDP is assumed to grow by 3.5% per year and population by 0.97% per year on average during the period 2010-2030. Conforming to stylised facts of long-term economic growth, capital is assumed to grow at the same rate as GDP and long-term employment growth is equal to population growth.

Table 3.1 Baseline and other scenario assumptions: percentage changes for 2010-2030

	Brazil	Central Africa	Indonesia	World
GDP volume growth rate	118.9	140.8	144.8	99.4
GDP volume average yearly growth rate	4.0	4.5	4.6	3.5
Population growth rate	19.4	56.3	18.8	21.4
Population: average yearly growth rate	0.9	2.3	0.9	1.0
GDP volume per capita growth rate	83.3	54.1	106.0	64.2
GDP volume per capita average yearly growth rate	3.1	2.2	3.7	2.5
Base yield growth rate	24.4	65.3	32.0	39.0
Base yield average yearly growth rate	1.1	2.5	1.4	1.7
Extra yield increase due to closing gap	10.6	34.1	15.2	17.9
Decrease in availability of land due to environmental protection	-45.1	-26.1	-21.2	-17.4

The economic and population developments diverge among countries and regions. Real GDP growth in Brazil, Central Africa and Indonesia are projected to be 0.5 to 1% greater per year than world GDP growth. The annual population growth in Brazil and Indonesia is expected to be a little less than world popula-

[1] A projection of the future based on most likely economic trends, assuming no changes in policies. This scenario is used as a reference for policy scenario comparisons.

tion growth while Central Africa faces significant population growth of 2.3% per year, which is almost twice the world average (USDA, 2010). This strongly drives demand for food for this region and results in high labour force growth, which may support further economic development.

Agricultural yield growth rates are taken from FAO (Bruinsma, 2003). Globally, agricultural yields increase by 1.6% per year. For Central Africa, 2.5% per year yield growth is assumed whereas this figure is 1.1% for Brazil and 1.4% for Indonesia.

The Baseline scenario assumes no policy changes and no new policies in the simulation period, but only applies existing policies and those agreed upon for the future, such as milk quota abolition in EU in 2013. Concerning biofuel policies, the mandatory biofuel targets are not implemented in the BA scenario and biofuel subsidies are kept fixed in the simulation period. This specification of biofuel policy in the BA scenario can lead to an increase or decrease in biofuel production as the result of macroeconomic developments and/or crude oil price changes. The crude oil price development, which is crucial for biofuel production growth, is endogenously determined in the model, though significantly driven by assumed future crude oil production as derived from IEA (2008) and EIA (2009) data.

In addition to the BA scenario, three consecutive scenarios are investigated. They implement three different policy options leading to biodiversity protection. These options are implemented stepwise in a cumulative manner and the associated scenarios are defined as follows. The *Protected Areas* scenario (PA) expands the area of natural ecosystems already protected by 20% at global level. Since these areas, identified as forest, woody land and other land (e.g. tundra), could potentially be used for agriculture, the worldwide availability of agricultural land decreases by about 17% in this scenario. The regional increase of land protection and therefore decrease of land availability depends strongly on the biophysical characteristics of the region. Brazil, for instance, will face a particularly strong decrease of agricultural land availability of 45% of all land suitable for agriculture, while this figure is 26% and 21% for Central Africa and Indonesia, respectively (see Table 3.1).

In many regions of the world, there is a wide gap between actual crop yields and potential yields (IAASTD, 2008). Closing this gap is an important means to increase agricultural production that would reduce land expansion. The *Closing the Yield Gap* scenario (YG) assumes a 40% higher increase of the annual yield growth compared to that of the Baseline scenario. This scenario limits yield increases to a maximum of 1.5% per year in countries with a small yield gap (including OECD countries excluding Mexico and some OECD countries from

Eastern Europe). The most pronounced additional agricultural land productivity growth is expected to be in Central Africa where average yield growth rates increase an extra 34%.[1] The assumed additional increase in yield growth rate for Brazil is only 11% and 15% for Indonesia.

Post-harvest losses in the food supply chain are estimated to range up to 23% for developed countries and up to 50% for developing countries (Lundqvist, 2009). It is expected that a cutback of these losses would lead to a decline of agricultural production and less pressure on land or an increase in agricultural production without extra land use necessary. In the *Reducing Losses* scenario (RL), we assume a reduction of post-harvest and supply-chain losses by a third (33%), resulting in efficiency gains of 7% for all world regions (Ten Brink, 2010).

In LEITAP, the scenarios are built as a recursive updating of the database in three consecutive time steps: 2010-2013, 2013-2020 and 2020-2030. Three periods are distinguished to take into account the future CAP and WTO agendas and timing of their implementation.

Before the Baseline scenario begins, a pre-simulation scenario is run (for a period of 10 years) to translate the exogenous GDP targets to the overall country-level technological change which is endogenously determined within the model (Hertel et al., 2004). This technological change is in turn exogenous in the remaining simulation experiments. The sectoral total factor productivities (TFP) are a linear function of country level technological change. Following Central Planning Bureau (CPB, 2003), we assumed different technological development by sector and common trends for relative sectoral TFP growth. CPB assumed that all inputs achieve the same level of technical progress within a sector (i.e., Hicks neutral technical change). We deviate from this approach by using additional information on yields from FAO (Bruinsma, 2003) for land-using sectors. For the non-land using sectors we assume Hicks neutral technical change.

[1] The percentage additional growth has been calculated for individual crops and livestock commodities having different base yield growth figures. The percentage growth presented is an aggregate for all primary agriculture, with weighted averages of individual crops.

4 Key results from the Baseline scenario

The Baseline scenario shows a significant increase in production and consumption of agrifood commodities in Central Africa driven by strong income (GDP) and population growth in this region (Table 4.1). Also, compared with Brazil and Indonesia, Central Africa has a low initial income and consumption level, which leads to higher income elasticities of consumption. This is an additional factor behind a significant agrifood consumption growth (158%) in Central Africa.

The macroeconomic growth also drives non-food consumption increases in all regions, although differences in consumption growth between regions are much lower than in the case of agrifood products. The agrifood production increase leads to an increase of agricultural land use. This increase is especially pronounced in Central Africa, where agricultural land expands by more than one third (36%: see Figure 4.1, where the BA column reaches up to 1.36, where 2010=1). The rather strong yield increase (65% over the period 2010-2030) prevents a further expansion of agricultural land.

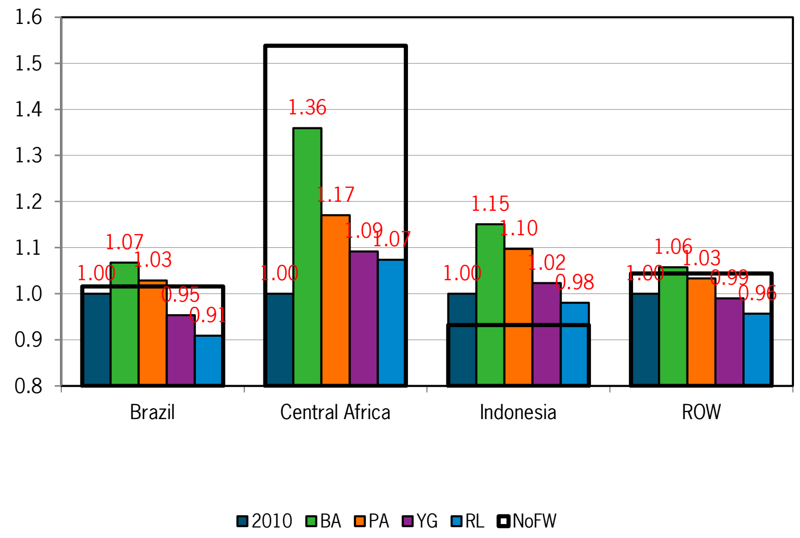
Despite the abundant availability of land in Central Africa, the region is and will remain a large net importer of agricultural commodities. Strong population growth will lead to strong increased demand for food and agricultural land. Consequently, marginal land is taking into production. The model outcome of a tenfold increase of imports in 2030 relative to 2010 is not caused by lack of land, but by low land productivity. On the other hand, Central Africa's net exports of 'other commodities' significantly increase; apparently, Central Africa has a comparative advantage in 'other commodities'.

Model outcomes suggest that increasing world food demand is fulfilled by Brazilian net-exports. Brazil can meet this demand as it uses only one third of its area suitable for agriculture (see table 1). This leads to an increase of Brazil's trade surplus in agrifood products. In addition, Indonesia strengthens its positions as agrifood (net) exporters. This comes, however, at the expense of forest areas, just as in Brazil (Figure 4.1): in 2030 Brazil and Indonesia will use 14.7 and 11.5m ha of former forest and woody land, respectively, representing 2.8 and 20% of all forest and woody land in these countries in the BA scenario.

Table 4.1	**Baseline scenario results**				
		Brazil	**Central Africa**	**Indonesia**	**Rest of World (ROW)**
		AGRIFOOD COMMODITIES			
Production growth (%)	2010-2030	40	146	59	30
Production (billion 2001 $)	2030	181.6	315.3	124.4	7175.0
Agricultural land use growth (%) a)	2010-2030	7	36	15	6
Private consumption growth (%)	2010-2030	48	158	48	33
Share of agricultural land used in total available agricultural land (%)	2030	38	80	57	66
Net Export (billion 2001 $)	2010	13.8	-0.4	4.1	-22.4
Net Export (billion 2001 $)	2030	14.6	-4.0	8.2	-27.8
Real consumer price growth (%)	2010-2030	-28	-36	-3	-13
Consumer purchasing power change (%)	2010-2030	151	183	149	116
		BIOFUELS			
Production growth (%)	2010-2030	171	1326	798	373
Production (billion 2001 $)	2030	17.9	0.3	0.4	109.8
Net Export (billion 2001 $)	2010	0.6	0	0.0	-0.6
Net Export (billion 2001 $)	2030	1.3	0	0.1	-1.4
		OTHER COMMODITIES			
Production growth (%)	2010-2030	100	120	132	87
Production (billion 2001 $)	2030	1966.2	652.3	830.3	121102.6
Private consumption growth (%)	2010-2030	136	173	128	100
Net Export (billion 2001 $)	2010	-21.4	-15.3	32.7	-17.5
Net Export (billion 2001 $)	2030	-47.5	26.2	77.8	-103.8
Real consumer price growth (%)	2010-2030	-2	4	19	1
Consumer purchasing power change (%)	2010-2030	125	143	128	102
		HOUSEHOLDS' LIVELIHOOD			
Real households' income (%)		123.3	146.8	146.4	102.4
Real consumer price index (CPI) (%)		-3.3	-13.9	15.4	-0.4
Consumer purchasing power change (%)		126.6	160.7	131.0	102.8

a) Compared to land use for agricultural production in 2010.

Figure 4.1	Agricultural land-use development from 2010-2030 and the non-forest and woody land area (NoFW) suitable for agriculture: agricultural land use in 2010=1.



Note: The NoFW area cap reflects the area that is defined as area suitable for agricultural production that does not include forest and woody land. If the column is higher than the capped area (horizontal) line, the expansion of agriculture is only possible with pulling forest or wood land into agricultural land (See Appendix 1, for an extended Figure). b) agricultural land use in 2010=1.

The countries or regions analysed in this study increase their biofuel production. This is a consequence of increasing crude oil prices, which will reach approximately 220 dollars per barrel in 2030, assuming 70 dollars per barrel in 2010. That price makes biofuel production profitable. In percentages, biofuel production in Central Africa and Indonesia increases are much greater than in Brazil, but Brazil is one of the biggest producers and remains the biggest net-exporter of biofuels to the rest of the world.

Worldwide purchasing power of households measured as the difference between income and price changes more than doubles in the 20 years between 2010 and 2030. High per capita GDP growth leads to a strong income increase while technological progress suppresses the price increase or even leads to a price decrease in the agrifood sector.

5 Impact of intervention measures on land, production, consumption and trade

5.1 Impact on competing land claims

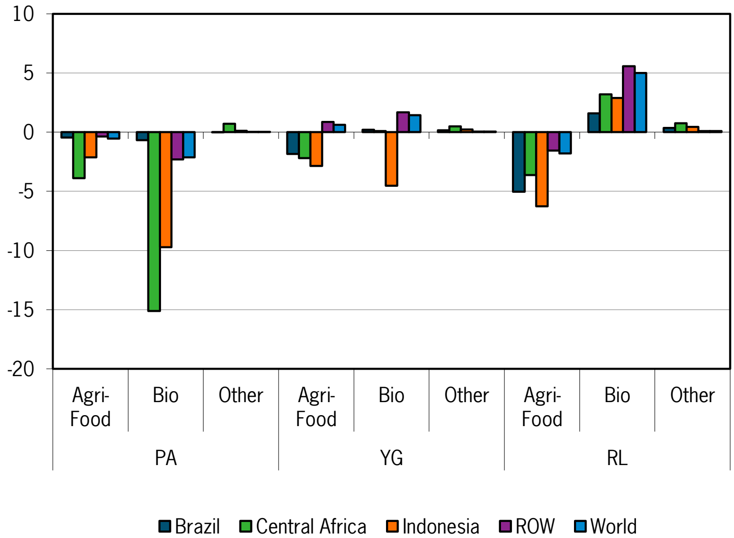
Baseline scenario results show that agriculture competes for land with forest and nature. Since forest and woody land generate no economic benefits (according to the model), increasing demand for food leads to land use changes at the expense of ecologically vulnerable areas. In order to protect such areas and their biodiversity, interventions are needed. As a first step, we apply a limit to agricultural land expansion possibilities by reducing the land availability via measures that prevent land use change from forest/woody land into agricultural land. To ensure adequate food production while biodiversity rich areas are protected, increased yields' and reduced food losses' scenarios are designed. Expanding protected areas (by 20% worldwide, as defined in the PA scenario) leads to a significant decrease in the availability of forest and woody land for agricultural use, since there is a cap on expansion. Figure 4.1 shows the effects of such measures: compared to the expansion of agricultural land areas under the BA scenario, agricultural land area in Brazil, Central Africa and Indonesia is reduced by 3.5%, 14% and 4.5%, respectively. The consequence is that agricultural production in Brazil and Indonesia still expands into forest and woody land: the column indicating the agricultural land use in 2030 under the PA scenario exceeds the capped area (see Figure 4.1). The scenarios Closing the Yield Gap and Reducing Losses, subsequently imposed onto the PA scenario, reduce the agricultural land areas in Brazil by 15% in 2030 compared to 2010, yet while agricultural expansion is not using forest and woody land in Brazil, agricultural production in Indonesia still comes at the cost of natural ecosystem areas.

5.2 Impacts on production, consumption and trade

Implementation of all three scenarios leads to a decrease in the area used by the agricultural sector compared with the Baseline scenario (see Figure 4.1). However, this decrease has different impacts on countries' total agricultural production and consumption, depending on the scenario. The expansion of protected areas leads to a worldwide decrease of agricultural land and agrifood production compared with the BA scenario by 4.3% (Figure 4.1) and 0.5% (Figure 5.1) respectively, and an intensification of land use (i.e. using more labour and capital per hectare of agricultural land) resulting in higher yields. In the Closing the Yield Gap scenario, the lower acreage of agricultural land is accompanied by increased production due to yield growth. In turn, the Reducing Losses scenario leads to an increase in effective available production since the production volume decrease less than 7% (against the base scenario level) whereas the assumed efficiency gain due to reduced losses is 7% for all world regions (see section 3).

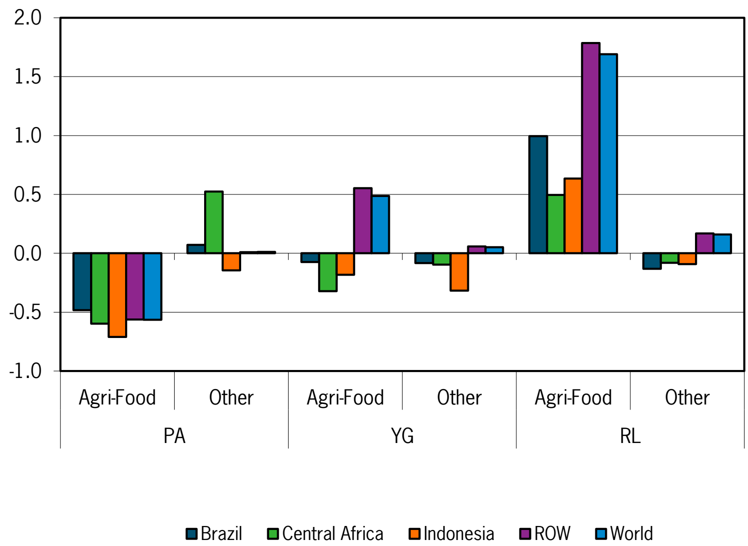
In general, the PA scenario results in increased competing claims for land use, while applying the YG and RL measures may reduce those claims. In the PA scenario, food production out-competes other land users: agrifood production is decreasing but much less than biofuel production in all regions (see Figure 5.1). At the same time, the production of other commodities' is hardly affected as these non-agricultural products generally do not use land. The protected area scenario has the greatest impact on agrifood and biofuel production in Central Africa and Indonesia where, respectively 93 and 69% of land available for agriculture is being used. In Indonesia, this land includes former forest land. A strong decrease of agrifood and biofuel production leads to almost twice as much net-imports of agrifood products by Central Africa and a decrease in net exports of Indonesia. The additional supply of agrifood products on the world markets comes from the Rest of World countries that lower their net-imports. Increase of area protection leads to a slight decrease (between 0.5% and 0.7%) in agrifood consumption in all analysed regions (Figure 5.2).

Figure 5.1	Production volume: % difference relative to Baseline scenario in 2030



In closing the Yield Gap and Reducing Losses scenarios, the efficiency increase in the agrifood supply chain makes the production level a confounding indicator of competition for land that does not allow straightforward interpretation of the model outcomes. In the YG scenario, the production in one region can decline because production increases in other regions that export more or import less due to higher yields in the own country or region. In the RL scenario, the waste reduction in the food supply chain leads to less production without a negative effect on the availability of food.

Figure 5.2	Private consumption volume: % difference relative to Baseline scenario in 2030

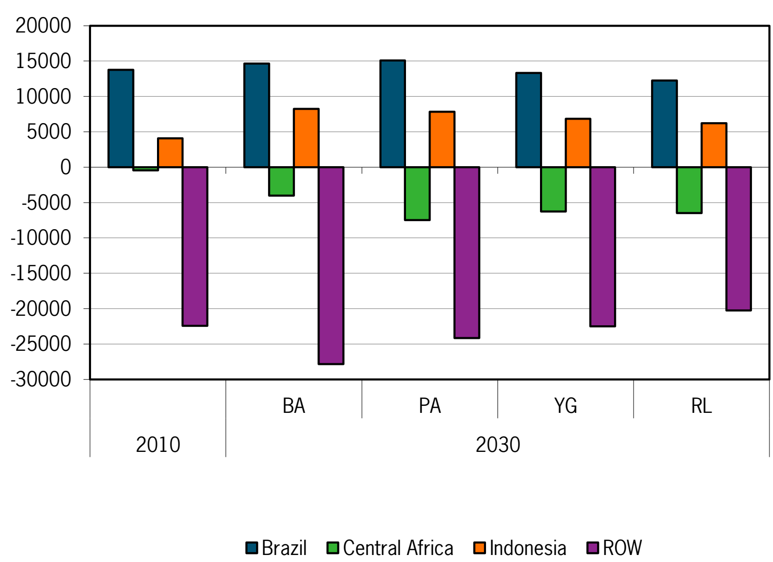


The production numbers in the YG scenario clearly suggest that globally the competition for land decreases when compared to the situation in the Baseline. The world agrifood and biofuel production increases above baseline level due to productivity growth (Figure 5.1). However, this production growth does not result in an increase of agrifood consumption above the baseline level in all three analysed regions (Figure 5.2). Shortages in agrifood production are especially pronounced in Central Africa, where net-imports increase in comparison to the BA scenario (Figure 6.1). Reduced land availability in the PA scenario results in Central Africa in a fall of agricultural land area below the baseline level and makes low productive land too expensive for agricultural production to be profitable. Hence, in the YG scenario, agricultural production does not reach the baseline level and net imports increase compared to the baseline. In contrast, Brazil and Indonesia see their net-exports of agri-food products lower than in the BA. Also, Indonesian biofuel production is below the BA level. This indicates that productivity growth decreases tensions on world agrifood markets. At the same time, however, there are still competing claims for land in Central Africa and to a smaller extent in Indonesia.

Worldwide, less waste in the agrifood supply chain implies higher consumption and at the same time, less production of agrifood commodities compared with the BA scenario. Globally, the agrifood consumption is 1.7% higher (see Figure 5.2 on consumption) and production 1.8% lower than BA levels (see Figure 5.1 on production). However, in the case of Central Africa, the increase in the agrifood consumption is largely supplied from imports, which are above the BA scenario level (see Figure 5.3 on net exports).

The production capacity realised by increasing efficiency in the food supply chain is used to produce biofuel commodities. Biofuel production increases in all analysed regions in the Reduced Losses scenario (see Figure 5.1 on production). Globally, it is 5% higher than in the BA scenario.

Figure 5.3 **Net exports of agrifood products in US$ millions 2001 in all scenarios in 2010 and 2030**

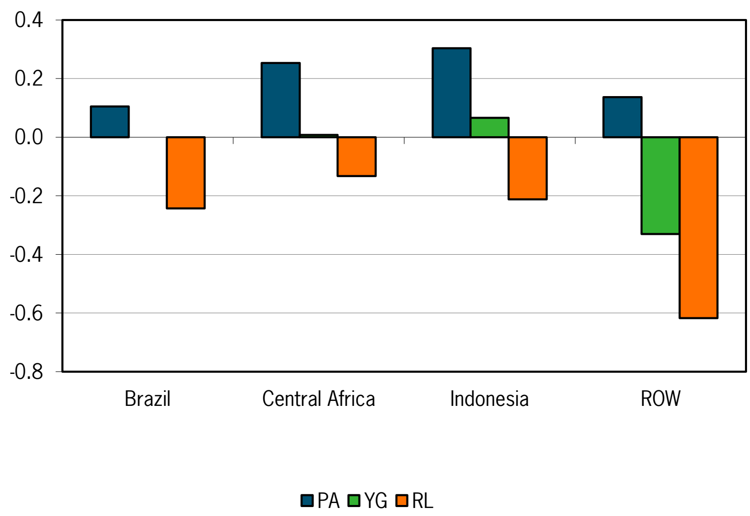


All in all, these results show that the combination of the three analysed measures (protecting nature, closing the gap between actual and potential land productivity and reduction of losses in the agrifood chain) significantly reduces competition for land. The three scenarios allow higher food consumption using less agricultural land than in the BA scenario. Also, they do not require forest and woody land conversion into agricultural land except for Indonesia where eventually 4.4% of its former forest and woody land will be used to produce agricultural goods. Combinations of all three policy measures change consumption patterns towards more food and less 'other goods' compared with the BA scenario in all three countries/regions analysed.

6 Price and income effects with impacts on food security

Does increased food availability (for consumption) also imply an improved food security? To answer this question it is important to examine price developments of food and income developments at a household level. Compared to the Baseline scenario, an increased protected area of natural ecosystems leads to a worldwide, yet small increase of agrifood consumer prices, as production levels decline and demand remains high (Figure 6.1). In Indonesia, 3% price increases are expected, with just over 2% in Central Africa and 1% in Brazil. Increasing yields reduce the protected area effect on agrifood prices to almost zero in the analysed regions and result in a price decline in the rest of world by about 3%. Reduction of losses in food supply chains brings agrifood prices below the Baseline scenario level in all regions.

Figure 6.1 **Change of real price of agrifood consumer basket in % compared with Baseline scenario in 2010-2030**



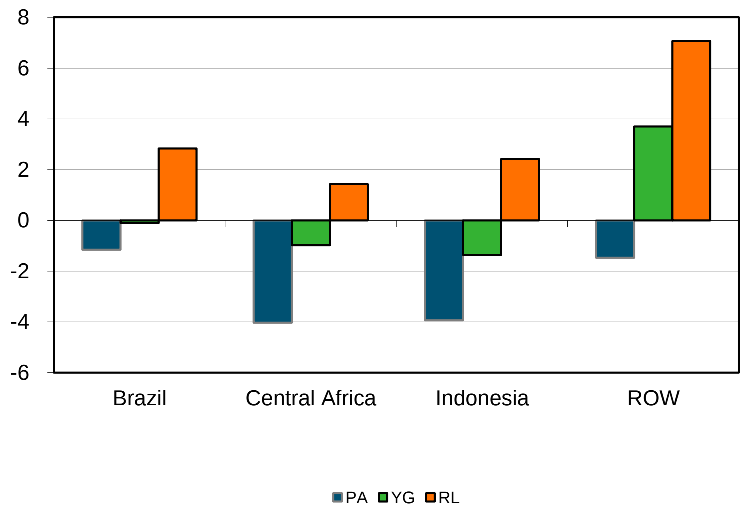
The effect of all these measures on the overall real price of the consumer basket is very small. Interestingly, the expansion of environmental protection leads to a somewhat lower overall price level in Brazil while increased efficiency in agrifood chain results in slightly higher prices. In other regions, the opposite effect is observed. In Brazil, a food price increase does not influence the overall consumer price index significantly because of its low share of agro-food products in the consumer basket (14% versus 50% in Central Africa and 31% in Indonesia). At the same time, a decrease of agrifood production moves the primary production factors from agriculture to other sectors, which increase production and decrease prices in those sectors.

To analyse the impact of the implemented measures on household welfare, we need to compare price changes outlined above with income effects generated in different scenarios. The calculated household consumer purchasing power, which is the difference between change in income and price levels, shows that the analysed scenarios do not have a major impact on household income: in the worst case the consumer purchasing power deteriorates by around 1.5% in 20 years compared with the Baseline scenario. In the best case, it improves by nearly 1%.

A decrease in areas (land) available for agriculture (PA scenario) leads to a drop in household purchasing power in all analysed regions compared with the Baseline scenario. Yield improvements (YG) reduce this drop again in Central Africa and in Indonesia, although not in Brazil, which (as a major exporter) suffers from decreasing world demand for agrifood products. In the Reducing Losses scenario, income of households recovers in all regions and reaches a higher level than in the BA scenario. The more efficient food supply chain results in decreasing prices of food products and the movement of resources from agrifood production to more profitable production activities that affect income positively.

The ability of consumers to buy food is more affected by the proposed measures than their ability to buy other goods (Figure 6.2). The purchasing power of other commodities decreases by only 0.6% in the analysed scenarios compared with the Baseline scenario while the purchasing power of food commodities in Central Africa and Indonesia drops by 4% and in Brazil by more than 1% in the PA scenario compared with the Baseline scenario. However, yield improvements reduce this loss significantly for all three regions and efficiency improvement in food supply chain (RL scenario) brings the ability to buy food products to a higher level than in the Baseline scenario for all analysed regions. Therefore, the combination of all 3 policy measures improves the food security of households in all 3 analysed regions.

Figure 6.2	Consumer purchasing power of agrifood commodities growth in % compared with Baseline scenario in 2010-2030



7 Conclusions from global model projections

According to the Baseline scenario, food demand increases in the years up to 2030. As a result, agricultural land expands to increase production. In Brazil, Central Africa and Indonesia, the increase of agricultural land implies that forest and woody lands in these countries/regions are used for agricultural production, which leads to a loss of biodiversity. In order to preserve natural ecosystem areas, the area (natural ecosystems) already protected is set to increase by 20%. As a result, more forest and woody land is protected, but not necessarily all of this type of land. This measure results into a significant reduction of land available for agriculture in all three countries/regions. Still, agricultural area expands at the cost of forest/woody land in Indonesia and to a limited extent in Brazil. Capping agricultural land expansion (through protecting ecologically vulnerable areas) affects agricultural production levels and food security negatively, especially in Central Africa and Indonesia. Competition on land between agriculture and biodiversity rich areas is reduced by applying measures to increase yields and reduce food losses along the supply chain. Applying such measures improves food availability and reduces food prices compared to the Baseline scenario. The effect is an improved food security situation compared to the baseline scenario in all countries or regions analysed.

8 Developments in Brazil

In this case description we take the 'top-down' global analyses by the TEEB as reference and reflect on these findings from a bottom-up perspective of past, current and foreseen developments. We will emphasise our reflections on land dynamics with specific attention for the impact of different scenarios in the TEEB analysis on land protection, increased agricultural productivity and reduced losses in the food chain.

8.1 Model projection outcomes for Brazil

The Baseline scenario reveals an expansion of agricultural into forest and woodlands of 14.7m ha by 2030 relative to 2010. The economic gains are significant for Brazil; agricultural production increases by 40% and the net-export value goes up by USD873m for food commodities. Biofuels export increase also, though the export of other commodities does decrease pointing to the relatively worse competitive strength of non-agricultural commodities relative to Brazil's agricultural sector. Overall household income increases and consumer price indices decrease.

Introduction of the protected area (PA) scenario results in a increasing competing claim on land as the agricultural land decreases, resulting in less agricultural production, which causes food prices to increase. Through agricultural productivity increases (assumed to fill the gap between the agro-ecologically possible yields and the actual yield) and reduced losses in the food chain, agricultural production in Brazil is projected to achieve a 2% higher level than in the baseline in 2030, yet with a 15% less agricultural land area.

8.2 Land dynamics

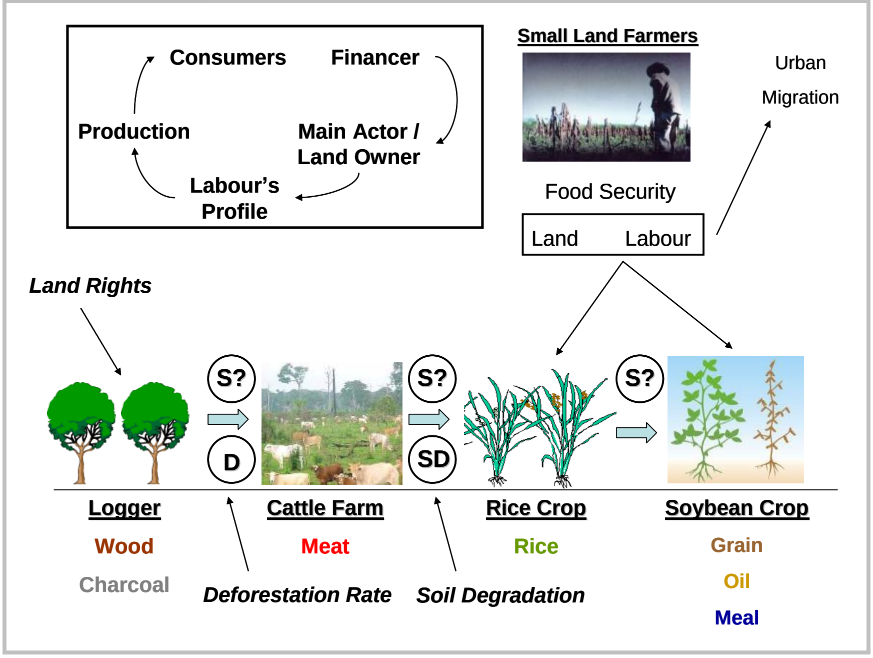
Scenario analyses of TEEB take land dynamics into consideration through price mechanisms: the increasing demand for food, feed and energy/biofuels is pushing up prices for agricultural commodities and land, resulting in further pressure on non-agricultural land to be converted into agricultural land. Increasingly we are aware of the need to maintain ecosystems services, as these provide direct and indirect benefits for realising current human desires and for future generations. The ultimate result of price mechanisms is the expansion of agricultural land into current natural lands. Gibbs and colleagues (2010) show this effect through remote sensing observations. They found that between 1980 and 2000 expansion of agricultural land came from expansion into intact forest (55%), disturbed forest (28%) and savannah (8%).[1] Other analyses and studies have also shown this indirect effect, known as Indirect Land Use Change (ILUC) to occur (European Union, 2010; DG Energy of the European Commission, 2010, Al-Riffai et al., 2010). This effect is particularly important to estimate the ultimate GHG balance for the production of biofuels. Apart from providing an alternative energy source, biofuels are primarily being stimulated because of the impression that they reduce GHG emissions by replacing fossil fuels. However, the gains in GHG reduction 'in the chain' are low because of the low radiation use efficiency of plants, the use of energy during production of the crops and for the production and application of inputs like fertilisers and other agro-chemicals, the low efficiencies in processes (Bindraban et al., 2009a, b). This efficiency relates to so-called direct effects. In addition however, many GHGs are produced due to clearing of natural lands for agricultural production; the ultimate effect of any additional claim on the production capacity of agriculture. Though the ultimate GHG balance differs per crop, biofuels from most crops would not comply to criteria for saving GHG. It is, in addition, essential to reduce the pressure on high bio-diverse and carbon rich ecosystems, as their destruction will not only harm the economy and ecology of the nations where they are situated, but that of world as a whole (Santilli et al., 2005). The TEEB analyses assess such ultimate or indirect effects also, which is in line with all scientific findings.

It is however much more debated whether specific agricultural activities and expansion of cultivation areas of specific crops or meat production on grasslands lead to deforestation, because of the indirect relations.

Bindraban and Greco (2008) elaborated the chain of agricultural activities to unravel the dynamics of land use in the Amazon Biome boundaries in Brazil (Figure 7 below). The schematic overview of the dynamics in land use provides some relevant issues like a most common land use dynamic, who owns the land, who are the potential financers, labour profile, etc.

[1] These are the pan-tropical numbers. Numbers for South America show a shift from shares from disturbed forest and savannah in the 1980s (both ¼, 50% from forest) to forests in the 1990s (63% from forests, 13% from disturbed forests and 20% from savannah).

Figure 8.1 **Land dynamics in Brazil**



At first, forest or savannah land is cleared for wood and charcoal by national and international loggers. Concessions are given by the government and in several cases illegal logging has been reported. Much public land has no land title and loggers may simply claim land. Logging for timber generally does not lead to a complete clearing of the land as useable trees are extracted only. The demand for wood and related products is expected to grow at a rate of 1% globally, with Asia increasing its imported share, while Brazil taking a more important role in export (FAO, 2007; Pepke, 2002). Subsequently, the land is further cleared and converted into grassland by sowing with grass species like Brachiaria that performed well under the prevailing soil conditions for cattle raising to produce meat. Generally, investments to maintain soil quality are not made. The stocking density remains low and the productivity of the grassland itself is subject to degradation. Improvement of productivity per hectare would be obtained with high investments to increase the pH (i.e. reduce the acidity) of the soils by liming and to improve the P-status by fertilisation, but appears economically unfeasible. It remains attractive therefore to expand into new lands as profit margins are higher, also because public land is cheaply acquired (Anualpec 2008). After 3 to 5 years, these grazing lands may be converted into cultivation land.

For that, trunks are burned and roots uprooted. The first arable crop to be grown is dryland rice. After 2-3 years, other crops including soybean generally occupy the land. For these crops, the lands should be well cleared to allow mechanical operations.

Due to this complex process with multiple actors, multiple products and various phases, no direct claim can be made between the rate of deforestation and the various activities. It might be argued that it is more related to charcoal production, or cattle ranging, rather than to soybean production for instance. Still the overall pressure on the agricultural frontiers in Brazil results from these various claims and pressures on the forest, savannah and land resources.

Soy, however, is believed to be the single most important economic activity justifying the large investments in massive infrastructural developments (Laurance et al., 2004). There are indications though that these agricultural activities are indirectly related, such as a close correlation found for soybean and deforestation (P. Barreto, IMAZON - personal communication). It remains important therefore to monitor these dynamics and to identify a package of measures that impact on all the activities. It is also for the ambiguous relations that individual or private enterprises can claim not to cause deforestation, neither can they prove, when required for purposes of certification, that they are not indirectly causing deforestation.

This implies that aggregate measures on deforestation and human activities should be coordinated at governmental level. Here national governments seem to have a prime responsibility for on-the ground activities while the international community should create conditions to prevent undesired developments. A range of measures such as reduced demand for commodities, protection of high-biodiversity areas, payment for environmental services and the like may have to be agreed upon internationally.

8.3 Land protection

The protection area scenario shows that biodiversity in the region is protected as expansion of agriculture into these areas is curtailed. However, this measure does lead to the reduced production of food, increased food prices and reduced household income. It is not likely that this will be the final outcome of such a measure. Because of the increased food prices and the reduced availability, the region is likely to increase its food imports from other regions. Hence the pressure on land resources is likely to be displaced to other countries or regions. Land protection will therefore have its particular indirect effects also. If ultimately the total volume of demand is not reduced land expansion will be displaced or reduced demand due to impoverishment may reduce pressure on these indirect effects, which might not be considered to be a desirable development.

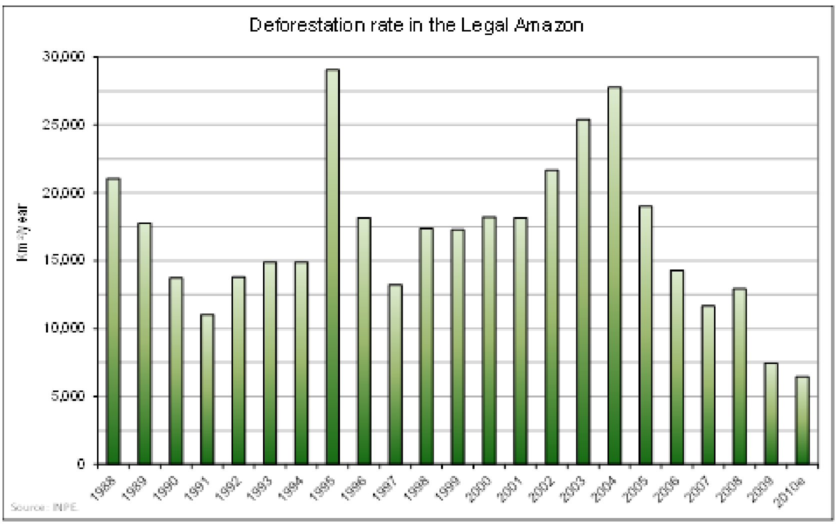
An example of an initiative to protect high bio-diverse areas has been the Amazon Moratorium for soybean production (Van Berkum and Bindraban, 2008). Soybean traders and processors from Brazil agreed in June 2006, in consultation with the European industry and societal organisations like Greenpeace, to avoid selling soy that is cultivated on land in the Amazon Biome that is deforested after July 2006. The moratorium would apply for two years and in June 2008, the Association of the Brazilian Vegetable Oil Industry and the Association of Brazilian Cereal and Oil-seeds Exporters (Abiove), took the initiative to extend the Amazon Moratorium with one year up to 23 July 2009. The moratorium has continually been extended, now for another year starting July 2010. Abiove claimed that the measures aiming at preventing lodging in the tropical forest areas are successful. Others, however, claimed that production was displaced to other regions in Brazil, especially in the Cerrado biome, another vulnerable ecosystem with high biodiversity values (Kamphuis et al, 2011) providing habitat to more than 10,000 plant species, of which 44% is endemic and 1,268 vertebrate species, of which 9% is considered to be endemic (Myers et al., 2000). or to neighbouring countries. Discussion are underway between stakeholders to impose a similar model for protecting the Amazon for cattle ranging that is increasingly perceived as a major contributor of deforestation.

Still however, this intervention may be relevant from an ecological perspective, protecting some high biodiverse areas. Brazil has imposed rather strict rules with regard to the use of natural lands. Rivers are for instance protected by prohibiting clearing of natural lands along the banks. The width of the protection area increases with the width of the river. In addition, land owners should maintain 20% of their lands untouched within the Cerrado biome, while 80% of the land owned in the legal Amazon cannot be cultivated. Initially this legal reserve was introduced to secure supply of wood for fuel. When the need for such reserve became superfluous over time, the legislation remained in place but was not actively enforced. Since the 1980s the objectives of the legal reserve legislation have been changed based on mere environmental considerations. Also the legislation changed over time, reflecting the constant tussle between environmental and agricultural interests. For instance in 1997 properties below 100 ha were exempted from the 80% limit (Mueller and Alston, 2007). The authorities appear, however, to have insufficient capacity to impose strict implementation of the regulations. Also, land owners claim that their foregone benefits ought to be compensated by the international community because of the eco-system services provided.

The National Space Research Institute INPE, which monitors deforestation through satellite images, reveals a clear reduction in the rates of deforestation since 2004 (Figure 8.2). The 645,100 ha of deforested land over the period August 2009 to July 2010 (2010 in the graph) corresponds to a reduction of 77% over 2004.

These observations have provided valuable information to the Brazilian government to take necessary and immediate actions for instance by putting strict criteria on credit facilities for both public and private funds, which appears more effective in reducing deforestation than fines given by the government to illegal deforestation.

Figure 8.2	Deforestation in the Amazon as monitored by INPE, the National Space Research Institute (2010).



8.4 Increased agricultural productivity

Brazil's most important agricultural products (in value terms) are soybean, sugarcane and corn (maize). Although yields vary from year to year due to weather influences the development of the production per hectare of these three crops have been one of gradual increase. Soybean yields in the early 1990s were around 2.2-2.3 ton/ha and have reached 2.6-2.9 ton/ha on average in most recent years (FAO stats). Sugarcane yields have increased from 60 ton/ha in the first half of the 1990s to 75-80 ton/ha lately. Maize yields are around 4 ton/ha these days, up from 2-2.5 in the early 1990s. These figures show that productivity growth has been significant. By taking into account soybean, corn, cotton, rice, dry bean and sugarcane, Nasser et al. (2010) have calculated that over the period 1996-2009 the average annual growth rates of yield was 3.01%. The authors state that pasture area intensification during the last decade and the use of arable area for second cropping (e.g. wheat or maize cropping in February-June over areas used for soybean production in October-February) contributed significantly to production and yield increases in the last 15 years. Both aspects have not been addressed carefully enough in the global simulation models used by OECD, FAO, FAPRI nor in GTAP/LEITAP, Nasser et al. claim. These two aspects would also imply less need for converting forest land to cropland in Brazil or for using marginal land for agricultural production expansion. To emphasise this, Nasser et al. present figures that indicate a consistent declining trend since 2005 in deforestation rates in Brazil' s Amazon biome and also in other regions of the country.

The perspective of further increase of production and yields of Brazil's most important crops are promising. As reported in Van Berkum and Bindraban (2008), several sources claim that Brazil's cropping area can expand by 170m ha with investments in new production and productivity increasing technology (among which genetically modified crops) and in infrastructure, without expanding agricultural areas over forest area. According to USDA/FAS (2003) some 80m ha can be realised by turning grassland into arable land. Next to that, USDA/FAS' estimates of the possible soybean acreage expansion are based on information from Brazil's agricultural research organisation EMBRAPA that indicate that about 65m ha in the Cerrado can be made suitable for arable cropping against relative low costs. In addition to that, EMBRAPA indicates that investments in soil fertility improvements can make 10m ha of 'degenerated' land available for soybean cultivation. Another possibility is to invest in an integrated system of livestock and arable farming. In such a system grassland will be used for soybean production for a number of years after which it returns into grassland. Rotation of land has economic gains (land is being used more productive) and environmental benefits (soybeans fixes nitrogen, an important nutrient for grass). A 30m ha of extensively used grassland would be suitable for this kind of integrated farming system (Van Berkum and Bindraban, 2008: 29).

The above indicates the significant contribution that the increase in yield and the increase in cropping intensity, i.e. the number of crops that can be grown on an annual basis, can make to alleviate the pressure on expansion into natural resources. This balance appears favourable for Brazil, which is well endowed with agricultural resources, such as relatively high rainfall, though it may not necessarily apply to other regions in the world. While some environmental and ecological consequences of increased human activity can be evaluated at the regional scale such as deforestation, other environmental impacts such as emissions of GHG should be evaluated globally; e.g. beyond the Brazilian territory.

Apart from reduced claims on land, the reduction on claims for water and other nutrients are of equivalent importance. Bindraban et al. (2010a) estimate the demand for water with increasing food demand. Water for transpiration by plants is almost linearly related to the total food volume. Depending on the diet, they estimate that up to an equivalent of one billion additional hectares of land with a grain yield level of 5 t/ha would be needed to collect sufficient rainwater. Alternatively the water productivity on the current 1.5bn ha of additional land would have to increase by 70% which is beyond practical options as it reached theoretical limits on using rainwater. Therefore a combination of both increased productivity on the current land is needed, though not easily attained (Molden et al., 2010), and expansion of agricultural land. Bindraban et al. (2010b) propose to increase red meat consumption in developing nations through enhanced grassland production to exploit the production potential of grasslands and to prevent grasslands from conversion into arable lands.

This latter option is receiving much attention in Brazil - the ability to effectively exploit the grassland potentials remains yet to be seen. Exploiting the production of grassland calls for great investment to improve pasture productivity and the need for greater management efficiency given high interest rates and land appreciation in the agricultural frontier, which may have limited the intensification in pasture productivity (Luís Gustavo Barioni, EMBRAPA Cerrado, Pers. Comm.). Greater economic returns for investments were expected for intensifying production per animal rather than increasing stocking rates. Therefore meat production is generally increased through feedlots by feeding of cattle with crops produced on arable lands. The meat production per head or expressed per hectare of grassland may increase, but the grassland productivity itself hardly increases and stocking rates remained unchanged. Much research is ongoing at present in Brazil to identify new grass species.

8.5 Sustainability

Starting with the club of Rome in 1972, a politically strong signal was given that humankind should use its natural resource base in a conscious manner, even calling for austerity to ensure fulfilment of the needs of future generations (Meadows and Meadows, 1972). Sustainability concerns have culminated in the World Summit in 1992 in Rio de Janeiro, Brazil with the Rio Declaration on Environment and Development and Agenda 21. It has become a notion that is globally accepted though its definition and implementation is subjective, depending on societal development level and priorities, personal preferences, and the like.

Since the 1990s, the principal characteristics of sustainable development (in the agricultural, fisheries and forestry sectors) concerned the conservation of land, water, plant and animal genetic resources, the development of agricultural practices that were environmentally non-degrading, technically appropriate, economically viable and socially acceptable. Despite these global concerns and international calls for sustainable development, progress has been slow or even negative. Current discouraging developments in food security (FAO, 1999), climate change (IPCC, 2007), over-fishing, degradation of land quality (Oldeman, 1999), pollution and overuse of water (Cosgrove and Rijsberman, 2000), and poorly managed animal production (Steinfeld et al., 2006) indicate that the effectiveness of the exploitation of the natural resource base has been excessive and not sustainable.

Over the past decade, a different approach is under construction to progress more effectively towards sustainable practices. The agrifood supply chains increasingly operate at a global level with global implications of supply and demand as analysed in the TEEB study. These developments link societies from all over the world. The awareness of this strong interdependence implies that global platforms are needed to negotiate their desires. These desires should be transformed into sets of criteria that can be monitored through indicators which can be implemented in reality by the actors involved in the production chain. Several initiatives have developed in various sectors such as the Palm Oil sector (Roundtable on Sustainable Palm Oil; RSPO), Forestry Sector (Forest Stewardship Council; FSC), Agricultural Certification (Sustainable Agricultural Network; EURPGAP), Organic Certification (e.g. International Federation of Organic Agriculture Movements; IFOAM); Fair Trade Criteria (e.g. Fair-trade Labelling Organisations International; FLO) and the Coffee sector (Common Code for Coffee Community; 4Cs).

Specifically related to the developments in Latin America related to the rapidly growing production of soybean, a multi-stakeholder and participatory process Round Table on Responsible Soy (RTRS) was set up to secure that future expansion of soybean production is carried out within a sustainable framework. This framework safeguards ecological sustainability limits in field activities and looks after social and economic aspects. However, it is not capable of controlling the geographical dimension of land expansion, because this goes beyond the control of individual actors and enterprises as discussed in the section on land dynamics. Because land expansion can be seen as an aggregate measure for the increase in total volume of demand for food and non-food commodities, the geographical dimension of sustainability comprises issues such as the loss of biodiversity, the increased GHG emissions from land conversion, ought therefore to be regulated by national and international governmental rules and regulations. Though the Amazon moratorium for soybean is an illustration of a self-imposed regulatory mechanism between NGOs and the private sector, to this avail, more structural government regulation appears essential.

9 Case Central Africa: likelihoods of scenario assumptions and results

In this case we will reflect on the results of the scenario presented in chapters 4-6 based on past, current and foreseen developments in Central Africa. In this study Central Africa refers to the countries south of the Sahara, down including the Congo basin. The region includes the regions typically identified as East Africa and West Africa.

9.1 TEEB analysis

As a result of strong increases in both population and GDP, it is projected that the production and consumption of agrifood commodities in Central Africa will increase by 1.5 times the current levels.

In the year 2000, Central Africa (East and West Africa) had about 56.8 and 79.9 = 137.7m ha of cropland and 237.5 and 186.8 = 424.3m ha of grazing land. For Central Africa, the TEEB baseline scenario shows a significant increase of the agricultural area by 36% in 2030. As a result, by 2030 80% of the land potentially suitable for agriculture will be used for this purpose (see Figure A1 in the Appendix). This will be mainly at the cost of natural ecosystems, which area decreases with 76.5m ha. Despite the expected strong increase in productivity (current trends in cereals and oilseed crops in Eastern Africa are 0.5% per year, whereas in Western Africa, they exhibit an increase of respectively 0.43 and 4.9% per year), it is expected that Central Africa remains a large net importer of agricultural commodities.

Additionally, increasing fuel prices substantially increase the profitability of and thus the demand for bio-fuels. As a result, it is expected that part of the agricultural production may go towards biofuels, instead of food production. However, increasing awareness of the food versus fuel debate, and the development of different sustainability frameworks and certification schemes for biofuels and their effects on GHG balances (such as the renewable energy directive - RED, and the principles of the Round table on Sustainable Biofuels - RSB), have led to more awareness worldwide.

9.2 Land dynamics in Central Africa

Across most of Central Africa increased agricultural production has been achieved by bringing more land into production (Lambin et al., 2003), where most of the expansion has been at the expense of natural vegetation cover. Crop land expansion is dominated by small holders who, in traditional shifting cultivation production systems, and under the pressure of increasing population size and increasing dietary requirements, have found themselves returning more and more often in the same area. Increasing livestock densities and increased cropping frequencies of newly cleared land, without a proper rehabilitation of the soils used for agricultural production lead to unsustainable soil degradation. Usually, cultivation started in the wetter and more fertile areas, but currently expansion towards areas with reduced suitability for agriculture production is the logical trend.

In many countries in the region land tenure is not clear or disputed, with customary rights that are sometimes overlapping or centrally controlled access rights (e.g. Cotula, 2007; Verburg et al., 2009). As a result farmers appear to have little incentives to make improvements, like irrigation systems, that need large investments.

Also due to unpredictable weather conditions, of which extremes in the region are increased due to climate change, such as droughts and flooding leading to crop failure, the risk involved to invest in management measures such as fertilisation or pest and disease control, has become too large to be profitable on the short run (Conijn et al., 2011).

9.3 Land protection - conservation of biodiversity

For allocation of conservation areas in the scenarios maps with important eco-regions were combined with a number of biodiversity hotspot maps. The eco-region maps enables identification of areas with distinctly different ecosystems (see (Olson and Dinerstein, 2002) for eco-regions). The ambition set in the TEEB scenario was to protect 20% of each of 65 terrestrial eco-regions. The biodiversity hotspot approach identifies areas that have a high abundance of endemic species, i.e. species that will go extinct if they disappear in that region, and/or areas with a high biodiversity value that are vulnerable for disturbance and that are currently threatened (i.e. ≥70% of the primary habitat is already lost) ((Brooks et al., 2006)). The combination of the two types of strategies would protect the most vulnerable biodiversity across a wide range of ecosystems. This would be the areas that deserve a high priority for protection.

In the used protection scenario the ambition was to increase the area of protected area to cover 20% of each of 65 terrestrial eco-regions, which is in line with the target for 2020 set by the Convention on Biological Diversity (Stokstad, 2010). The results of this scenario for Central Africa project mainly expansion of protected areas in the horn of Africa (Ethiopia, Somalia and Kenya), and to some extent to the Congo basin. This has two main reasons that directly depend on the assumptions made for this scenario. The Horn of Africa covers a characteristic eco-region that is also identified as a hotspot area, i.e. an important eco-region with currently relatively little protection in combination with high pressure on the remaining areas.

In the scenarios, allocation of land use is based on the ecological and biophysical conditions and often neglects complex interactions between land use and people living in an area. This can be illustrated by the Tana River basin in Kenya, which gives a good example of the complex competing claims among different land uses and actors that may occur in areas with high conservation value. Not only are there competing claims between users up- and downstream (e.g. water, pollution, and siltation), also within the delta there is a complex interaction between designations and users of the area.

The delta is an important freshwater wetland area that hosts many species of special conservation concern (rare, threatened and endemic species of primates, birds and plants, (Terer et al., 2004)). A proposal to nominate the wetland to become a RAMSAR site, in which wise use of resources would be a key concept, has received serious opposition. The wetland is an important source of drinking water for pastoral communities and during periods of draught the wetland becomes an important grazing area. At the same time it is also one of Kenya's largest areas of irrigable land (50% of the undeveloped potentially irrigable land in Kenya, (Temper, 2010)). Next to small scale subsistence farming, current large scale agricultural activities are related to rice cultivation. There are, however, various projects underway to expand large scale production including sugarcane for food and ethanol production, and recently also foreign investors have shown interest to invest in production of greens and fruits for export.

These developments not only result in conflicts between conservation of the wetland area and increasing agricultural productions, but likely also increase tension between the main tribes living in the area. The river and associated wetlands provide important social and economic benefits to the local people. For the Pokomo tribe growing maize, rice and fruit trees in the floodplain and fishing in the lakes are the most important economic activities. In contrast the pastoralist Ormo and Wardei people depend on the wetland for water and pasture for rearing livestock, in combination with some shifting cultivation. The Ormo pastoralists and the agriculturist Pokomo tribe already compete for control over water and land resources ((Temper, 2010)). Additional (large scale) agriculture will further reduce the access of livestock to dry-season water and grazing resources, which will likely further increase existing tension.

The proposed and planned agricultural schemes for irrigated sugarcane and horticulture, and production of oil seed crops like jatropha (Jongschaap et al., 2007; van Eijck et al., 2010) are likely to attract many new labourers with families to the delta. This will result in rapid population growth and additional demand for land for subsistence farming and consumption of water (Bindraban et al., 2010; Gerbens-Leenes et al., 2009; Jongschaap et al., 2009). One of the often observed problems with irrigation schemes in (semi-)arid regions is that it leads to high population densities in areas with a low carrying capacity (e.g. (Johansson, 1991; Verburg et al., 2009)).

Some protected areas already exist in Tana delta, like the Tana River National Primate Reserve. In this area people practicing traditional small scale agriculture, pastoralism and fishing have used and developed the wetlands since a long time, managing to maintain the ecological balance. Rapid population growth, however, has been reported to increase pressure on the resources, resulting in forest fragmentation and improper farming practices ((Terer et al., 2004)). A measure by the Kenyan government to relocate some of the people from the park has been strongly opposed. Moreover since the start of this relocation plan, more forest has been witnessed to disappear.

Also in other examples of establishment of protected areas across Africa local people are relocated with the argument that people will conflict with the objectives of conservation and the potential of conflicts between people and wildlife. From the establishment of, for instance the Limpopo National Park it is known that relocation may result in conflicts between relocated people and people already living in the relocation area. One of the main problems identified with these relocation schemes is access to suitable and fertile land for (subsistence) agriculture (Milgroom 2010). In the example of the LNP, for instance, resettlers have been denied access to irrigable land.

The results of these cases show that protection of ecosystems where people depend on the natural resources for their livelihoods is more complex than the modelled scenarios show. In reality the situation is less black and white (protected or not protected) than can be included in the model exercises. In many cases people will still use the resources for subsistence, while in some cases also large scale production continues or even expands. However, despite traditional and small scale farming practices are often already taking place for ages in some of these areas, rapid population growth, and increasing demand for large scale food and bio-fuel production may compromise the ecological balance in these vulnerable ecosystems.

While farmers and communities in and close by the protected areas will be restricted in their development opportunities, producers outside protected areas may benefit from reduced production costs through improved delivery of ecosystem services provided by the protected areas, in combination with increasing product prices.

Effective protection of valuable habitat therefore needs integrated land-use planning at landscape level. This should include protection of the most vulnerable and valuable areas to protect its biodiversity and maintain the services these ecosystems provide, but also areas in which local people can practice traditional subsistence farming, and other areas should be designated for larger scale agriculture with sustainably intensified production, including efficient irrigation and fertilisers. The spatial configuration of these land-use practices should take into consideration the demand and delivery of ecosystem services and interactions between land uses. To create support from the local people they should be involved in such planning from early stages.

9.4 Increased agricultural productivity

The baseline assumes that the background yield growth in Central Africa is 2.5% per year, which by 2030 would result in a yield that is 65.3% higher than current yields (Table 2). Expected potential yield increases strongly vary among countries in the Central African region as used in the scenario assessment, while there are also strong differences between types of crops (Bruinsma, 2003). As stated in the introduction, current trends in cereals and oilseed crops in Eastern Africa are 0.5% per year, whereas in Western Africa, they exhibit an increase of respectively 0.43 and 4.9% per year (!). Of course, these trends should not be extrapolated beyond their biophysiological maximum!

The baseline scenario assumes that the past and current trends of technological advances in agricultural production and associated productivity increases will continue. Globally productivity would increase by 60% until 2030. Yet, it is the question if such strong improvements will be maintained given the many social, economic and environmental constraints. Although there is still a vast potential for expansion of irrigation in Central Africa, the majority of the suitable area is in the more humid areas. In the more arid areas increasing productivity through expanding irrigation will increase water shortages in downstream regions. A case study in the Central Rift Valley of Ethiopia shows that inefficient irrigation practices have profound effects for water availability in other parts of the same watershed, leading to increased salinisation of fresh water resources, further deforestation for cropland and livestock expansion and effects on fisheries ((Jansen et al., 2007)). In contrast to rain fed agriculture, during dry years irrigated agriculture results in higher water consumption caused by evapotranspiration. As a result of increasing extraction of water for irrigation, the end lake in this closed basin has decreased to 60% of its original size over the past years ((Jansen et al., 2007)) seriously affecting livelihoods of the people in surroundings of this lake.

One of the often observed problems with irrigation schemes in (semi-)arid regions is that it leads to high population densities in areas with a low carrying capacity (e.g.(Johansson, 1991)). An example from the Ethiopian Central Rift Valley shows that increasing irrigation farming and especially horticultural and floriculture (mainly roses) production attracts many new labourers and people looking for a job. Erratic rainfall and regular droughts have a strong effect on the mainly rainfed subsistence farming and production for the local market, resulting in high levels of food insecurity. As a result of the low productivity and increasing population density the limits of usable land have been reached and the size of cropland per household is decreasing ((Garedew et al., 2009)).

At a global or even regional scale the improvements in productivity will be partly offset by the effect of continuing soil degradation from overgrazing and unsustainable agricultural practices. The irreversible loss of agricultural land due to soil degradation is predicted to be at an annual rate of 0.1-0.2%. If and how such degradation is included in the TEEB assessments, should be carefully analysed.

In the used scenarios climate change results in an increase of global temperature by 1.6 °C by 2050 ((Bakkes et al., 2008; ten Brink et al., 2010)). Such temperature increase, however, will not be distributed evenly. Projections using a regional climate model shows that changes will increase much more than average in some areas, particularly in the highlands in East Africa and in West Africa, while increases will be less than average along the coastal regions of Kenya and Tanzania ((Verburg et al., 2010)). Precipitation in most of the central part of Central Africa is projected to slightly increase, while annual precipitation in the northern part of the region will remain the same ((Bakkes et al., 2008)). The western part (e.g. Senegal, southern part of Mali) is, however, projected to receive less rainfall annually. Although the mean precipitation increases, also intensity is likely to increase ((Shongwe et al., In press)), meaning more variability over the year. Analyses (Shongwe et al.) indicate that droughts in East Africa are likely to become less severe, but according (Sheffield and Wood) ((2008)) the frequency of droughts will increase. Hence more, but less severe droughts are expected for East Africa. In some regions the increased precipitation will be offset by higher evapotranspiration, resulting in a decline in average water availability ((Sheffield and Wood, 2008)). For both West and East Africa model projections show that the frequency of soil water deficits will further increase, especially at the beginning of the rainy season in September ((Sheffield and Wood, 2008)). Climate change may thus reduce productivity of certain crops, even if fertilisers and water are used more efficiently to improve productivity ((Fischer et al., 2005; Liu et al., 2008)). Hence, next to improving productivity of currently planted crops, it may also be necessary to shift to other crops that are more suitable under changing conditions.

This can be illustrated by an impact assessment of strategies to adapt to projected climate change in Mali's Office du Niger area where currently the focus is on irrigated production of rice in both the wet and the dry season ((Verburg et al., 2009)). During the dry season only 15% of the area is productive due to water shortages. Climate scenarios indicate a further reduction in water availability by 50% by 2020. The study showed that with 50% reduction in water availability strategies with alternative cropping systems score best on a number of sustainable development criteria for land based production and ecosystem functioning. The alternative in which rice production in the wet season is alternated with vegetables or sunflower in the dry season scores best on all land use functions compared to the baseline in which rice production is continued in both wet and dry season. Even a scenario in which the land is kept fallow in the off season, enabling land recovery and maintenance of irrigation canals, shows better overall performance of the sustainability indicators.

Closing the yield gap will decrease food prices and increase food availability through implementing (technological) measures increasing productivity. Farmers with access to the needed technology and suitable land area may benefit from such price increases, while in contrast farmers with no or limited access to these prerequisites to close the yield gap will not benefit and might even be driven further into poverty. Unclear and overlapping land tenure rights will reduce willingness of farmers to invest in technology needed to improve yields.

The current yield gap (the ratio between actual productivity and potential productivity) is estimated to be 0.15 in Eastern Africa and Central Africa and 0.22 for Western Africa.

9.5 Reduced losses in food chain

Data on losses through the food chain are largely missing, or dated ((Parfitt et al., 2010)). The estimated 50% for developing countries as used in the scenario as based on (Lundqvist et al., 2008) is one of the most cited accounts, but loss estimates strongly vary among regions and products. For instance losses for rice were estimated at 6-24% for West Africa ((Parfitt et al., 2010)), while those for more perishable fruits and vegetables were much higher. An important source of losses is caused by insects during storage.

Despite the uncertainties on actual loss in the various food chains and among regions, the scenario gives important insights into the potential effects of reducing these losses. Most losses occur during storage and transport. Technically it will not be very difficult to reduce such losses. In many areas in Africa and developing countries more in general, however, food chains supplying local urban markets are often characterised by many intermediaries and poor infrastructure and information leave farmers isolated from local and regional markets ((Parfitt et al., 2010)), challenging the (in TEEB) assumed 33% reduction in Central Africa.

Like in the increased yield scenarios, not all people in the region will experience the same benefits from lower food prices. Probably the increasing urban population will get most benefits from decreasing food prices. For subsistence farmers lower prices will have no or limited effect, while under the increased yield scenario access to land and water resources may become more difficult and prices of fertilisers can be expected to increase. Farmers with access to advanced techniques will likely benefit, but farmers that are not able to increase productivity might be driven into poverty as a consequence of lower product prices.

10 Competing claims in Indonesia: palm oil and alternative crops

10.1 Global and national drivers

A steadily growing population will require more and different products for their diets in the coming decades. As a result, more agricultural produce per capita is required. The growing requirements on agricultural products increase the pressure on land, as productivity growth cannot keep up with food end use requirements. Over the past 20 years in Southeast Asia, the productivity of cereal crops has increased by 2.3% and the productivity of oilseed crops has increased by 0.8% on an annual basis (oil palm by 1.3%) (FAOStat, 2010). The projections on annual food end use per capita (in MJ metabolic energy) and population size, show that the food end use will more than double at the year 2050 (Table 10.1).

Table 10.1 Current and projected population size (FAOStat, 2010) and developing diets (Bruinsma, 2003; Wirsenius et al., 2010) in the UN Region Southeast Asia and in Indonesia

Year	Food end use per capita	Population Southeast Asia	Food end use Southeast Asia	Population Indonesia	Food end use Indonesia
(-)	**(MJ a) ME b) year^{-1})**	**(M)**	**(TJ c) ME year^{-1})**	**(M)**	**(TJ c) ME year^{-1})**
2000	3,753	1,463	5.5	205	0.8
2010	3,987	1,719	6.9	233	0.9
2020	4,220	1,960	8.3	254	1.1
2030	4,453	2,158	9.6	271	1.2
2040	4,686	2,309	10.8	284	1.3
2050	4,919	2,415	11.9	288	1.4

a) MJ: Mega (10^6) Joules (= 239 kCal); b) ME: Metabolisable Energy; c) TJ: Tera (10^{12}) Joules.

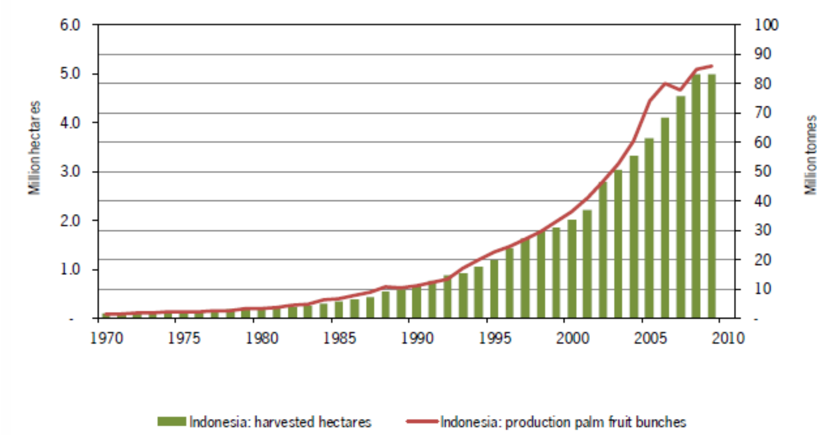
Additionally to food requirements, growing concern about climate change and energy security have led governments across the globe to explore alternatives for fossil fuel. Prominent among the potential solutions identified are biofuels. Policy interventions, especially in the form of subsidies and mandated blending of biofuels with fossil fuels are driving the rush to liquid biofuels. Possible feedstock for biofuel are vegetable oil, ethanol and the lignocellulose fraction of biomass, which through different techniques can be processed into liquid biofuel. Indonesia is among the world's most important producers of vegetable oils, through its production of palm oil.

10.2 Palm oil

On a productivity basis (litres per hectare), oil palm (*Elaeis Guineensis* Jacq.) is the most productive vegetable oil crop in the world. Oil palm outperforms other vegetable oil species that are not optimised to take advantage of long, warm and humid growing conditions that in principle would enable year-round growth and production of plant species. Year-round warm and humid growth conditions only occur in a relatively narrow band around the equator, which roughly defines the belt where oil palm can be most productive, depending further on soil characteristics and crop management. In general, oil palm is found in lowland areas that are easy to access and where more stable and favourable climate conditions can be found. However, in Indonesia, forest clearing for oil palm plantation development increasingly occurs in the hilly inlands of Central Kalimantan, whereas these lands have biophysical limitations for oil palm (Mantel et al., 2007).

The global demand for palm oil and its products has increased tremendously over the years, especially in Southeast Asia. As a result, vast forest areas have been converted into oil palm plantations (Figure 10.1), leading to increasing concern on the impact on the local environment and societies (Kamphuis et al., 2010). The total area dedicated to oil palm in Indonesia in 2009 was 7.3m ha, of which 5.1m ha mature and producing (Shean, 2009). The total oil palm area is expected to grow to 8.9m ha in 2012 (Santosa, 2008). The Indonesian government determined that approximately 32.0m ha would be suitable for oil palm production in Indonesia: 10.3m ha in Kalimantan, 7.2m ha in Sumatra, 6.3m ha in Papua, 0.37m ha in Sulawesi, and 0.29m ha in Java (Shean, 2009).

Figure 10.1 **Oil palm area harvested and production volume of fresh fruit bunches in Indonesia over 1970-2009. Data from FAOStat 2010 (Kamphuis et al., 2010).**

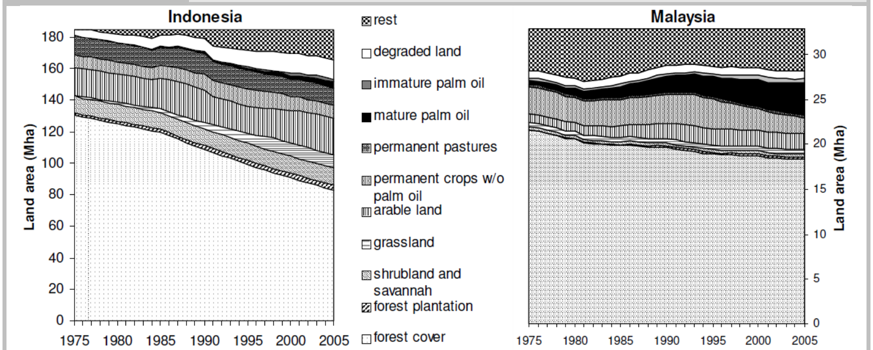


As can be observed from Figure 10.1, the production increase in Indonesia is merely the result from oil palm plantation expansion, and only little results from productivity increase per hectare (indicated by the red line significantly rising above the green bars). The Directorate General of Estate Crops in Indonesia estimated average/potential productivity ($t\ ha^{-1}$) for smallholders as 3.4/5.0 $t\ ha^{-1}$, for Governmental estate as 4.2/7.0 $t\ ha^{-1}$ and for Private estate as 4.1/7.0 $t\ ha^{-1}$. Reasons for not reaching potential productivity levels for smallholders can be found in little to no fertiliser applications on their land and in genetic stock growing on their properties generally inferior to that propagated by government and private estates. For governmental and private estate it appears that there is a serious under-investment in fertility management even in a producer group which has the financial ability to engineer higher yields (Shean, 2009). Small holders occupy 40-50% of all oil palm plantations, but account for 35% of the total crude palm oil produced (Shean, 2009; Sheil et al., 2009; Vermeulen and Goad, 2006).

10.3 Drivers for land use change

While land use change has occurred at large scale in Southeast Asia, the nature and driving force of it may vary in the region. In Indonesia, the largest change occurred in forest covered areas, (a decrease from 130m ha in 1975 to 86m ha in 2003), while agricultural land increased from 38m ha in 1975 to 48m ha in 2005, including the palm oil production acreage (Wicke et al., 2008). In Malaysia, deforestation was very strong until the beginning of the 1990s, slowed down considerable since then, but still happens today. The largest land use change was seen in land cultivated for oil palm, which increased from 0.6m ha in 1975 to 2m ha in 1990 and 4m ha in 2005, while other permanent crops, primarily natural rubber and coconut plantations, decreased strongly since the beginning of the 1990s, for a large part being replaced by oil palm (Figure).

Figure 10.2 **Land use change in Indonesia and Malaysia between 1975 and 2005 (FAOStat) (Wicke et al., 2008).**



The large loss in forest in Indonesia is caused by a web of interrelated drivers, including lodging, oil palm and other agricultural expansion, and forest fires. In Malaysia the most important causes vary per region and include timber extraction and shifting cultivation in Sabah and Sarawak, and conversion to agriculture in Peninsula Malaysia and most recent years in Sabah. In general, agricultural and forestry prices, population and economic growth and policy and institutional factors were responsible in land use change (Wicke et al., 2008).

The global credit crisis and the sharp decline in international palm oil prices during 2008 and 2009 (USDA, Oilword) may act to suppress expansion to a modest degree over the next few years, but as long as world edible oil demand continues to grow at current rates, there will be an impetus to increase production inside Indonesia (Shean, 2009).

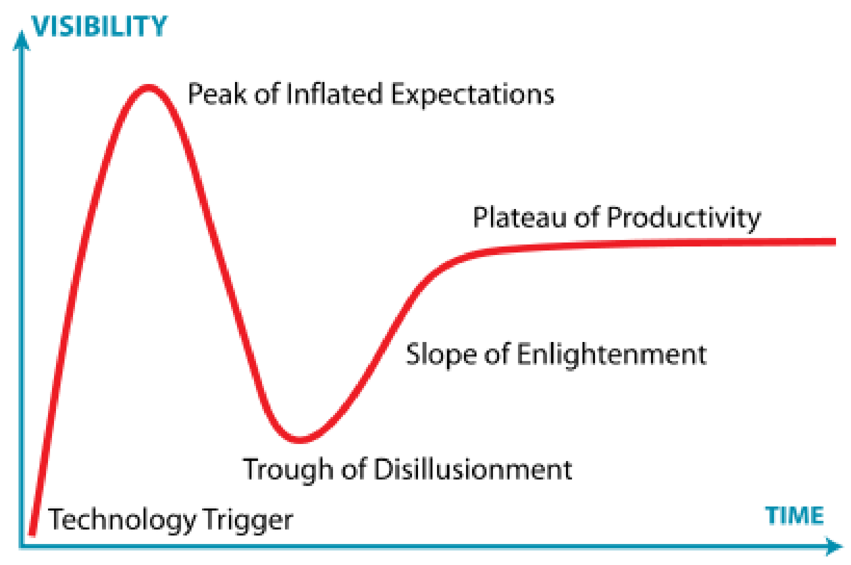
It appears unlikely that political or economic forces will forestall the current trend, though possible impediments have been suggested, such as a moratorium on forest clearing and timber extraction, a revocation of outstanding palm plantation development licences, a moratorium on future licenses, or lastly global environmental legislation, which explicitly prohibits the import of edible palm oil or its products (oleo-chemicals) from land converted from tropical forest. There is a current international movement in the European Union and in the United States to prohibit the import of palm-based biodiesel and prohibit the use of palm oil as a feedstock for biodiesel production. However, despite the evolving politics of international biodiesel regulations it is unlikely that anything other than a significant drop in global palm oil prices and/or demand will derail the current growth trend in Indonesia (Shean, 2009).

10.4 Alternative crops: jatropha hype cycle

The continuous expansion of palm oil acreage and its detrimental effects on biodiversity trough deforestation has initiated the search for alternative crops with high oil content. Jathropha might be such an alternative. The hype around jatropha in the biofuel sector in Indonesia is described in line with the Gartner hype cycle; See Figure 10.3 (Fenn, 1995). General descriptions of the 5 distinguished phases (*in italics*) come from Wikipedia and are specified for the Indonesian biofuel and jatropha case. [1]

[1] This section also benefits from experiences and background information from two recently funded projects, the NWO project Agriculture beyond Food (2009-2014), *Jarak: the commoditization of an alternative biofuel crop* (Jatropha curcas), and the EVD Indonesia facility 2009 for private sector development (2010-2012), *Integrated Improvement of jatropha cropping systems*.

Figure 10.3 **Gartner hype cycle (Fenn, 1995).**



In the hype cycle, the 'Technology Trigger', is the first phase or breakthrough, product launch or other event that generates significant press and interest.

In this case it is the deployment of jatropha as a renewable source of energy that was firstly triggered by high oil prices by governments around the world, and biofuels being placed as a number one substitute for fossil fuels. This phenomenon made South-eastern Asia assumingly a prominent exporter of biodiesel, as palm oil based biodiesel seemed clearly ahead in oilseed land use (acreage) and in productivity (Jayed et al., 2009). Of the cropland in South-eastern Asia (92.3m ha, FAOStat), 5.4m ha is used for oil palm, which is more than 50% of the global oil palm acreage (10.1m ha) in the year 2000. Recent studies have identified 45m ha of land to be suitable for oil palm production in Asia (OFID, 2009). Indonesia is expected to emerge as a major player on the biodiesel market, based on its oil palm production. FAO (2008) projects Indonesia's biodiesel production to grow from 600m liters in 2007 to 3bn liters by 2017, about 12 per cent of total world production.

In the following phase, the 'Peak of Inflated Expectations', a frenzy of publicity typically generates over-enthusiasm and unrealistic expectations. There may be some successful applications, but there are typically more failures.

From 2003, Indonesia's fossil oil production started to decline. Indonesia became a net importer of fossil oil and in the light of the fact that world oil prices started to rise at the same time, the Government developed a new energy policy for the country. The promotion of biofuel production forms an important part of this policy. Originally the production of biodiesel from palm oil and bio-ethanol from sugarcane and cassava was emphasised. High commodity prices and discussions over the loss of biodiversity (palm oil) and the use of food crops for fuel production casted some doubt over the viability and sustainability of these biofuel production systems. The cultivation of *Jatropha curcas* as an additional feed stock for biofuel production has been promoted ever since.

The Department of Energy and Mineral Resources has taken the lead in promoting this source of energy, arguing that Indonesia is an almost ideal place for growing biofuel feedstock. First, according to the Department, sufficient land would be available and capacity exists for improving relevant biotechnology. Second, from an environmental perspective, not only is biofuel environmentally friendly, but biofuel feedstock would even contribute to Indonesia's biodiversity. Third, growing biofuel feedstock would offer opportunities for community participation and the biofuel industry would provide work to many currently unemployed (Legowo, 2008).

In the case of jatropha, as described in the *Claims and Facts on* Jatropha curcas L. report (Jongschaap et al., 2007), high expectations on potential acreages and productivity levels demonstrated by oil palm in the region were also attributed to jatropha and its valorisation through the bio-refinery concept (Manurung, 2007). Separately observed characteristics on seed oil content and oil quality in combination with the potential small scale farmer involvement and marginal lands, contributed to the 'Peak of Inflated Expectations' (Jongschaap et al., 2007). Especially the claim that jatropha would thrive on marginal land, added to the expectations and hopes of millions. The Indonesian President Yudhoyono emphasised in 2006 that 'environmentally friendly biofuel could help to reduce global warming effects due to fossil oil over consumption' and had more socioeconomic advantages: the biofuel initiative had to solve three major problems in Indonesia, namely, the energy crisis, high unemployment, and poverty (Amir et al., 2008).

Biofuel found its way into national policy. Presidential Decree no. 5/2006 concerning The National Energy Policy sets a target for the 2025 national energy consumption mix, in which biofuel provides 5 per cent of the total. Four main biofuel crops have been identified: oil palm, cassava, sugar cane and jatropha. Since a few years Indonesia promotes jatropha cultivation both on a large and a small scale and encourages foreign and domestic investments in this sector. In December 2007 jatropha plantation realisation was 121,200ha, mostly in the form of small scale holdings, whereas the total commitment by investing companies was 1.54m ha to be realised in 2010 and involving large plantations (Legowo, 2008). The Department of Energy in January 2008 mentioned a targeted credit distribution realisation in 2010 of USD4.2bn (Legowo, 2008). Presidential Decree 10 of 2006 installed a National Team for Biofuel Development (TIMNAS BBN) that was assigned to make a Blueprint for biofuel development, including jatropha. Biofuel promotion includes the creation of 'self-sufficient energy villages', but the bulk of policy is geared towards the macro level, where consumption targets are set and where national legislation should be adapted for 'simplification of licensing issues' and creating 'Special Biofuel Zones'.

> *'Trough of Disillusionment' — Technologies enter the 'trough of disillusionment' because they fail to meet expectations and quickly become unfashionable. Consequently, the press usually abandons the topic and the technology.*

The 'Trough of Disillusionment' for biofuels in Indonesia and jatropha displays various aspects. In contrast to the rosy picture sketched by the Department of Energy there are in fact serious concerns about the social and ecological implications large scale cultivation of three of these four biofuel crops. This applies in particular to oil palm, the crop with the largest production potential in Indonesia at present. The public debate on Food, Feed or Fuels, seriously put biofuel production in a bad light: land use change and more specifically the development of oil palm plantations in South-eastern Asia is identified as one of the biggest causes of rainforest clearance (FoE, 2006), and tropical deforestation due to agricultural expansion, logging and infrastructure development contributing between 10 and 30 per cent of greenhouse global emissions (Colchester et al., 2006; Schimel et al., 2001). The thrust in biodiesel production from oilseeds of palm and *Jatropha curcas* in Malaysia, Indonesia and Thailand is identified as 'seriously threatening environmental harmony' (Jayed et al., 2009). In Indonesia fires are used to clear the land and peat bogs are drained to plant oil palms, thus releasing millions of tons of carbon dioxide, making Indonesia the third highest contributor of CO_2 emissions in the world (Marti, 2008).

Additionally, jatropha failed to live up to its expectations. The shift from relative unknown species to commercial crop did not take off so rapidly, although predicted by others (Jongschaap et al., 2007). In fact, productivity rates remained low under smallholder conditions in Africa (GTZ, 2009), and in Asia. In general scientifically sound information on jatropha agronomy, socio economic issues and ecology is absent in scientific readings (van Eijck et al., 2010). While geneticists, agronomists and plantation managers are still learning about jatropha's potential to provide abundant sustainable feedstock for biofuels, the investment community has instead been witnessing value destruction (Hawkins and Chen, 2011).

Where initial projects have already started local producers have voiced their criticism, because selling prices are low and marketing channels as well as processing facilities are not developed yet. Whether this just reflects initial problems in setting up a new sector, or more structural problems, is not yet clear.

The development of jatropha as a commercial crop in Indonesia is occurring right at this moment. Studies on the commoditisation of other crops in the colonial era (Elson, 1993) or more recent past (Hartveld, 1996; Semedi, 2009), have signalled similar problems.

> *'Slope of Enlightenment' — Although the press may have stopped covering the technology, some businesses continue through the 'slope of enlightenment' and experiment to understand the benefits and practical application of the technology.*

Some of the more advanced companies in jatropha plant science and jatropha production (Embrapa, Plant Research International; Quinvita, the former D1 Oils Plant Sciences Ltd) continue to unravel the complexity of jatropha crop growth and production. The completion of the genetic genome in Brazil (Carvalho et al., 2008) and by SGI and Asiatic Centre for Genome Technology (ACGT) and by others in Asia (Sato et al., 2011) will provide the required information in plant breeding programmes. However it is a more complex task to annotate the genes afterwards to the required plant traits. Structural funding of scientific research by the European Union in FP7 aim 'to bring jatropha curcas a decisive step forward' (van Loo et al., 2010). The involvement of the private sector in Indonesia, such as supported by the EVD Indonesian facility 2009 has initiated several programmes that seek to explore the business opportunities for this crop.

However, complementary to studies on biofuel crops, the introduction of jatropha in Indonesia offers a unique opportunity to study the process while it is happening by socio economic research initiatives. These can build on previous work, for instance on how local governments and producers are anticipating the plans concerning jatropha development (Vel, 2008).

> *'Plateau of Productivity' — A technology reaches the 'plateau of productivity' as the benefits of it become widely demonstrated and accepted. The technology becomes increasingly stable and evolves in second and third generations. The final height of the plateau varies according to whether the technology is broadly applicable or benefits only a niche market.*

For biofuels and jatropha this 'Plateau of productivity' is not reached yet. Plant breeding and agronomy research will eventually contribute to the deployment of such a niche crop for Indonesia. The niche market (in comparison to oil palm) is set by the different oil type and oil quality, the different crop requirements on soil fertility and soil texture, and different production systems that may be integrated more easily with traditional farming and traditional production systems.

11 Major findings and concluding remarks

11.1 Major findings

World demand for agricultural commodities will increase to meet welfare and population growth and will lead to increased demands for agricultural land. This leads to complex and interrelated processes with direct and indirect effects that ultimately result in a loss of biodiversity.

The baseline scenario shows that increasing food demand will result in the substitution of forest and woody lands for agricultural production in the three focus countries of this study, and a corresponding loss of biodiversity. To preserve natural ecosystem areas, the model exercise assumes a 20% increase of currently protected land, resulting in a significant reduction of land available for agriculture in all three countries/regions. However, this measure cannot prevent the agricultural area expanding at the cost of forestry/woody land in Indonesia and Brazil. Capping agricultural land expansion adversely affects agricultural production and food security, especially in Central Africa and Indonesia. Biodiversity loses, though, can be reduced by applying measures to increase yields and reduce food losses in the supply chain. Applying such measures improves food availability, reduces food price increases and improves food security in all countries/regions analysed**.** Brazil and Indonesia remain important net-exporters of food, while Central Africa becomes more dependent on food imports.

These global and country/regional projections have been reflected upon from bottom up actual developments and local specific situations in three cases. The Brazilian case study provides detailed insights into land dynamics in the tropical forest area in the country, where deforestation is a complex process with multiple actors, multiple products and various phases. The initiative to protect high bio-diverse areas through the Amazon Moratorium for soybean production and strict criteria for credit facilities for public and private investments in those areas seem to have retarded the pace of deforestation. Further, recent technological developments have importantly contributed to increasing yields of the country's major crops, while options to apply second cropping on agricultural land could further increase land productivity. Investments in soil fertility improvements, use of modern technology and infrastructure would increase Brazil's agricultural land stock, without expanding agricultural areas over forest. This leads to the conclusion that the perspective of further increase of agricultural production and yields in Brazil are promising, reducing the pressure on biodiversity rich areas to be used for agricultural purposes.

The African case study points at many difficulties to achieve the results projected by the global scenarios (and based on the assumptions underlying the model outcomes). Actual cases of introducing protected areas show the complexity of such a process, as it often implies relocation of people, which results in conflicts on access to water and fertile land with people already living in the relocation areas. In practice there is a great variety of agricultural productivity between sub-regions in Central Africa. Options to increase productivity are limited by water shortage, soil degradation and frequency of drought. Closing the yield gap therefore seems difficult to achieve. Potential effects of reducing losses in the food chain are challenged because these chains are characterised by many intermediaries, poor infrastructure and market information.

The Indonesia case study shows the rapid expansion of palm oil area and production in the last two decades, while forest covered areas declined dramatically. It is unlikely that political or economic forces will forestall the current trend, though possible impediments have been suggested, such as a moratorium on forest clearing and timber extraction, a revocation of outstanding palm plantation development licenses, a moratorium on future licenses, or lastly global environmental legislation which explicitly prohibits the import of edible palm oil or its products (oleo-chemicals) from land converted from tropical forest. However, despite the evolving politics of international biodiesel regulations it is unlikely that anything other than a significant drop in global palm oil prices and/or demand will derail the current growth trend in Indonesia, while alternative crops like jatropha - a potentially valuable biofuel crop - are not commercially interesting yet, and its assumed positive effects on environment, biodiversity and small farmers' livelihood are questionable.

11.2 Concluding remarks

Expanding the area of natural ecosystems already protected by 20% at global level adversely affects food availability and food security. As worldwide availability of agricultural land decreases, prices for agricultural land increase, agricultural production declines and prices for food increase. Technology, aimed at increasing production per hectare of available agricultural land and/or to reduce losses in the food supply chain can ease the trade-off between ecosystems' protection and food production.

Production potentials can be increased by using better seeds, fertilisers and targeted nutrients to improve soil fertility, apply smart crop rotation systems, invest in training of and extension towards farmers, and in infrastructure, storage and market information systems. Technological solutions, though, can only be successfully applied if the right socio-economic and institutional conditions are in place. Indeed, productivity growth depends on the complex relations between agro-ecological (e.g. rainfall, soils), economic (e.g capital, labor) and socio-institutional (e.g. information, values/norms) factors, each of which can be linked to specific intervention measures to support productivity growth (e.g infrequent rainfall requires water management; capital shortage requires improved access to credits, etc.).

Our quantitative analysis indicates that it is possible to combine an international policy strategy of biodiversity protection and food security while world demand for agricultural commodities increases to meet welfare and population growth in the coming decades. However, case studies clearly indicate that measures to protect natural areas critically depend on legal enforcement of rules and options to relocate people from high conservation value areas towards places where they can build up their livelihoods. More often than not these critical conditions are not available. Moreover the case study on palm oil indicates there are strong economic (and policy) forces that cause large losses of forest. Alternatives such as jatropha are not commercially interesting yet, while there are serious doubts that assumed positive environmental and socio-economic effects will occur.

Also, case study descriptions show that perspectives to increase agricultural productivity growth are much better in Brazil than in Central Africa where countries have to combat water shortage, soil degradation and the anticipated increase of drought period due to climate change. The analysis indicates that the solution to the global problem of feeding the world in a sustainable way lies in local development, where obstacles towards increasing productivity should be removed and competing claims on natural resources be tackled. Solutions need an integrated approach in which interventions linked to agro-ecological, economic and institutional factors should be considered simultaneously.

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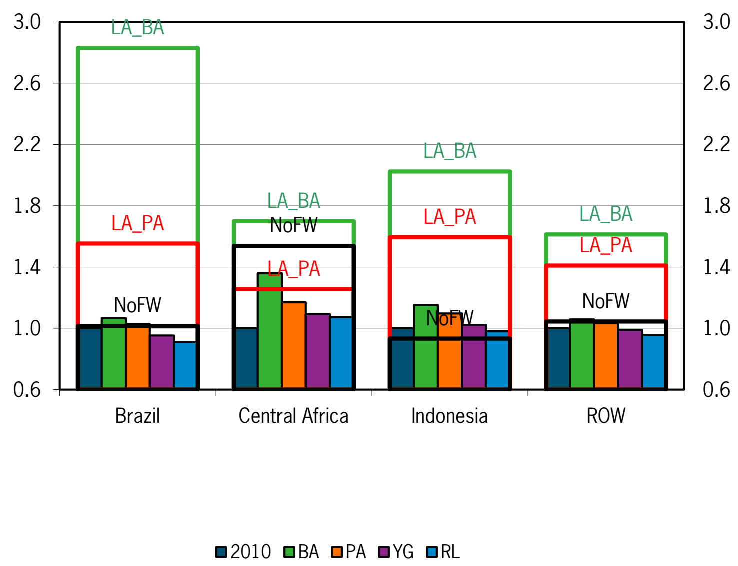
Appendix 1

Areas suitable for agriculture

The NoFW area cap in Figure A.1 reflects the area that is defined as area suitable for agricultural production that does not include forest and woody land. A column exceeding the capped area (horizontal) line indicates that expansion of agriculture is only possible with swapping forest or wood land for agricultural land. The LA_BA area cap reflects the maximal area that is suitable for agriculture in the Baseline scenario. The LA_PA area cap reflects the maximal area that is suitable for agriculture in the Protected Areas and other scenarios.

Figure A.1 **Areas suitable for agriculture under different scenarios**



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LEI report 2011-049