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Competing claims on land use for food and biodiversity

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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 analyzed 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 paper evaluates the impact of measures that simultaneously reduces 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. We have selected three regions, namely, Brazil, Central Africa[1] and Indonesia, which will be used to analyze 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).

2. Key features of the agri-food sector in Brazil, Central Africa and Indonesia

Agriculture is an important economic sector in Brazil, Central Africa and Indonesia (Table 1). The share of agri-food 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 about, respectively, 4 and 3 times higher than the world average, while the share of incomes earned (wage bill) in the agri-food sector in these two regions are even greater than the world average. A significant share of agri-food production is exported by Brazil and Indonesia, where Brazil has an 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, it comes at the expense of forests, woody land and savanna that are considered 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.

[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.

Table 1. Selected characteristics of agri-food sector in Brazil, Central Africa and Indonesia in 2010

	Brazil	Central Africa	Indonesia	World
Share agri-food sector in total value of output (%)	12	30	18	8
Share agri-food sector in total value of added (%)	7	25	18	6
Share agri-food sector wage bill in total wage bill (%)	4	35	20	5
Agri-food sector exports-production ratio (%)	16	8	13	9
Agri-food 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

Note: 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 Annex 1: Database).
Source: GTAP data base and own calculations.

3. Scenarios

This paper 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[2] (BA) assumes the macroeconomic development as used by the USDA (2010) in agricultural projections up to 2030 (Table 2). 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 stylized facts of long-term economic growth, capital is assumed to growth at the same rate as GDP and long term employment growth is equal to population growth.

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% per year greater than world GDP growth. The annual population growth in Brazil and Indonesia is expected to be a little less than world population 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.

Table 2. Baseline and other scenarios assumptions: percentage changes for 2010 - 2030 period

	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 availability land due to environmental protection	-45.1	-26.1	-21.2	-17.4

[2] 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 scenarios comparison.

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 for Brazil 1.1% and for Indonesia 1.4% per year.

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. With regards to 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 of biofuel production as the result of macroeconomic developments and/or crude oil price changes. The crude oil price development, which is crucial for biofuels 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 world wide 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 percentage is 26% and 21% for Central Africa and Indonesia, respectively (see Table 2).

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%[3]. The assumed additional yield growth rate increase 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).

4. Scenarios implementation

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.

[3] 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.

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.

5. Key results from the Baseline scenario

The Baseline scenario shows a significant increase in production and consumption of agri-food commodities in Central Africa driven by strong income (GDP) and population growth in this region (Table 3). 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 agri-food consumption growth (158%) in Central Africa.

Table 3. Baseline scenario results

		Brazil	Central Africa	Indonesia	Rest of World (ROW)
		AGRI-FOOD 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 (%)[1]	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
		HOUSEHOOLDS 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

Note:[1)] Compared to land use for agricultural production in 2010.

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 agri-food products. The agri-food 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 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 fact that the land is abundantly available 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 agri-food products. Also Indonesia strengthens its positions as agri-food (net) exporters. This comes, however, at the expense of forest areas, just as in Brazil (Figure 1): in 2030 Brazil and Indonesia will use 14.7 and 11.5 million hectares 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.

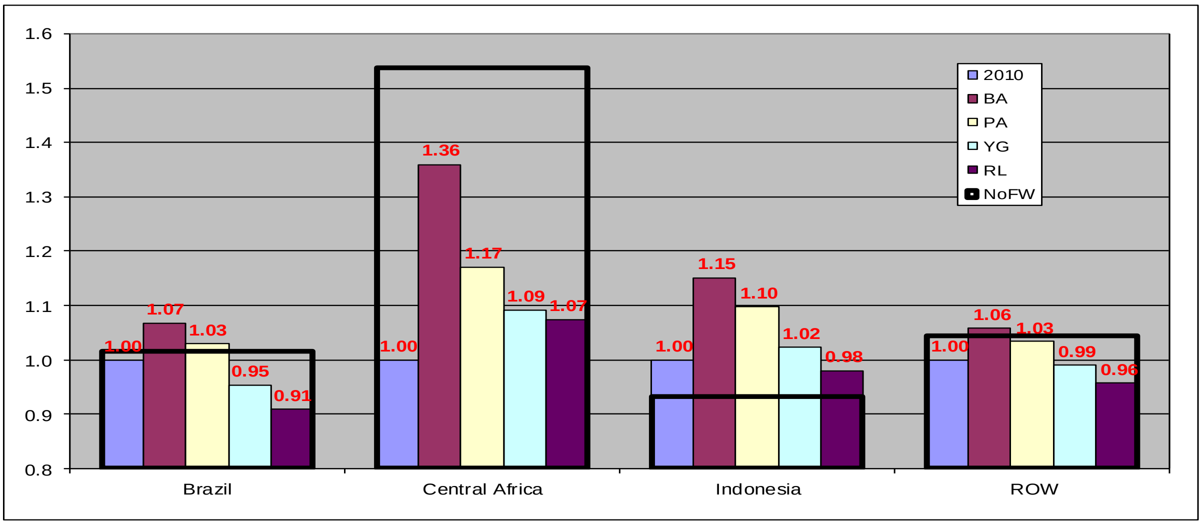

Figure 1. Agricultural land use development from 2010 to 2030 and the non-forest and woody land area (NoFW) suitable for agriculture: agricultural land use in 2010=1.

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 Annex 1, for an extended Figure).

The countries/regions analyzed in this paper increase their biofuels production. This is a consequence of increasing crude oil prices, which 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 much 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 strong income increase while technological progress suppresses the price increase or even leads to price decrease in the agri-food sector.

6. Impact of intervention measures on land related competing 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 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 1). The scenarios Closing the Yield Gap and Reducing Losses, imposed subsequently 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.

7. 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 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 agri-food production compared with the BA scenario by 4.3% (Figure 1) and 0.5% (Figure 2) respectively, and an intensification of land use (i.e. using more labor 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 users for land use: agri-food production is decreasing but much less than biofuels production in all regions (see Figure 2). 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 agri-food and biofuels 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 agri-food and biofuel production leads to almost twice as much net-imports of agri-food products by Central Africa and a decrease in net exports of Indonesia. The additional supply of agri-food products on the world markets comes from the Rest of World countries that lower their net-imports. Increase of area protection leads to slight decrease (between 0.5% and 0.7%) of agri-food consumption in all analysed regions (Figure 3).

Figure 2. Production volume: % difference relative to Baseline scenario in 2030

In closing the Yield Gap and Reducing Losses scenarios, the efficiency increase in the agri-food 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/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.

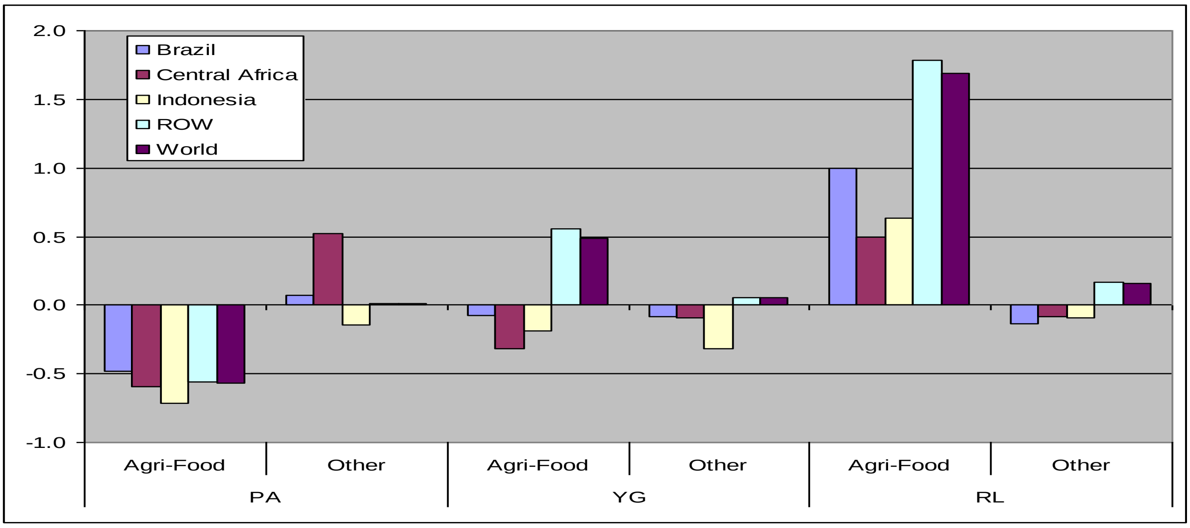

Figure 3. Private consumption volume: % difference relative to Baseline scenario in 2030

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 agri-food and biofuels production increases above baseline level due to productivity growth (Figure 2). However, this production growth does not result in an increase of agri-food consumption above the baseline level in all three analyzed regions (Figure 3). Shortages in agri-food production are especially pronounced in Central Africa where net-imports increase in comparison to the BA scenario (Figure 5). Reduced land availability in 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 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 agro-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 agri-food 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 agri-food supply chain implies higher consumption and at the same time less production of agri-food commodities compared with the BA scenario. Globally, the agri-food consumption is 1.7% higher (see Figure 3 on consumption) and production 1.8% lower than BA levels (see Figure 2 on production). However, in case of Central Africa, the increase in the agri-food consumption is largely supplied from imports, which are above the BA scenario level (see Figure 4 on net exports).

The production capacity realized by increasing efficiency in the food supply chain is used to produce biofuel commodities. Biofuel production increases in all analyzed regions in the Reduced Losses scenario (see Figure 2 on production). Globally, it is 5% higher than in the BA scenario.

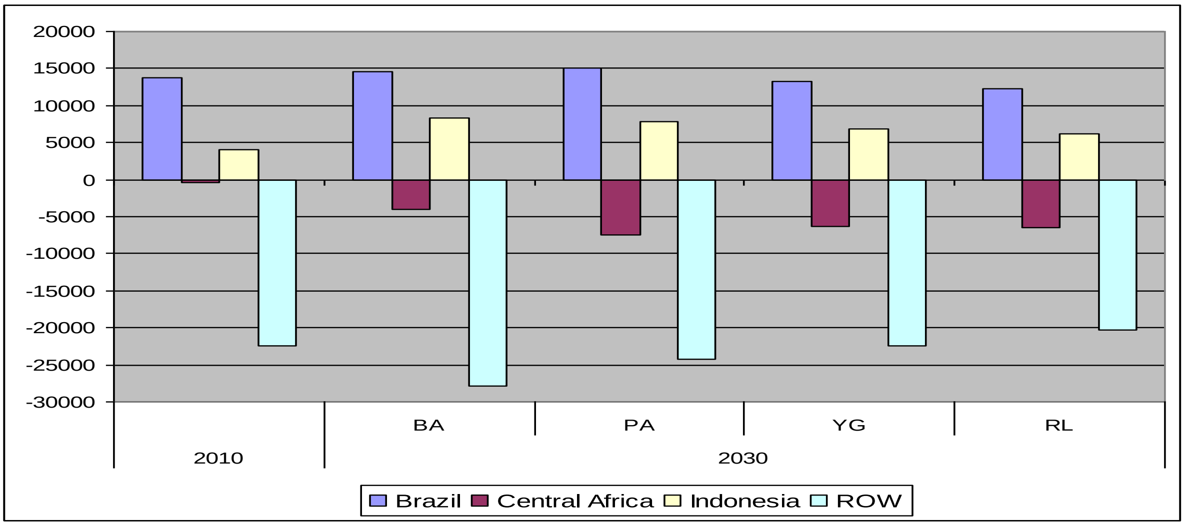

Figure 4. Net exports of agri-food products in US$ millions 2001in all scenarios in 2010 and 2030

All in all, these results show that the combination of the three analyzed measures (protecting nature, closing the gap between actual and potential land productivity and reduction of losses in the agri-food chain) significantly reduce 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 analyzed.

8. 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’s 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 agri-food consumer prices, as production levels decline and demand remains high (Figure 5). 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 agri-food prices to almost zero in the analyzed regions and result in a price decline in the rest of world by about 3%. Reduction of losses in food supply chains brings agri-food prices below the Baseline scenario level in all regions.

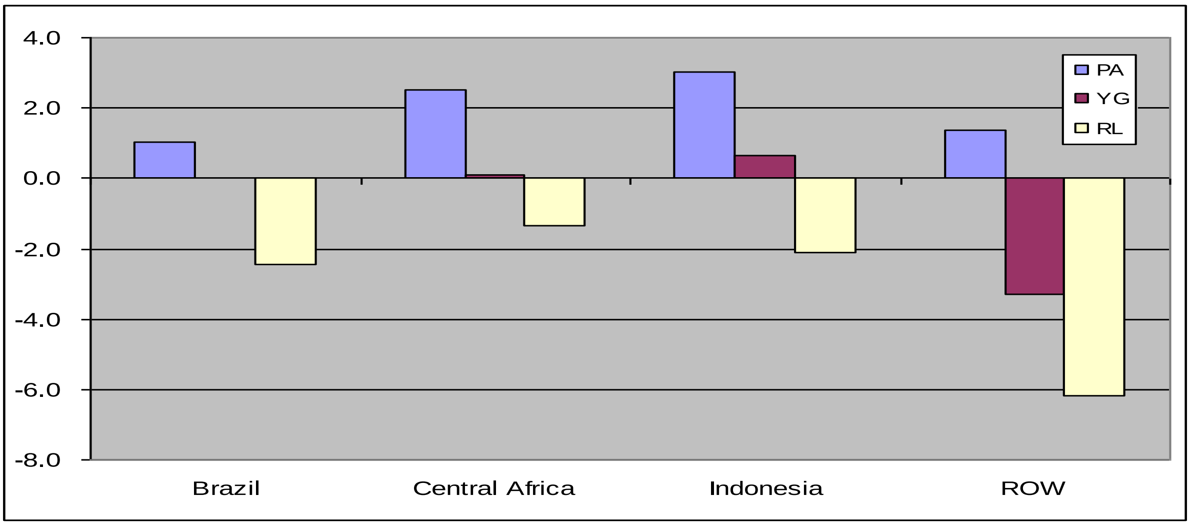

Figure 5. Change of real price of agri-food consumer basket in % compared with Baseline scenario in 2010-2030

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 agri-food 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 agri-food production moves the primary production factors from agriculture to other sectors, which increase production and decrease prices in those sectors.

To analyze 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 analyzed 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 analyzed regions compared with the Baseline scenario. Yield improvements (YG) reduce this drop again in Central Africa and in Indonesia, however, not in Brazil which (as a major exporter) suffers from decreasing world demand for agri-food 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 agri-food production to more profitable production activities which 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). The purchasing power of other commodities decreases by only 0.6% in the analysed scenarios compared with 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 analyzed regions. Therefore, the combination of all 3 policy measures improves the food security of households in all 3 analyzed regions.

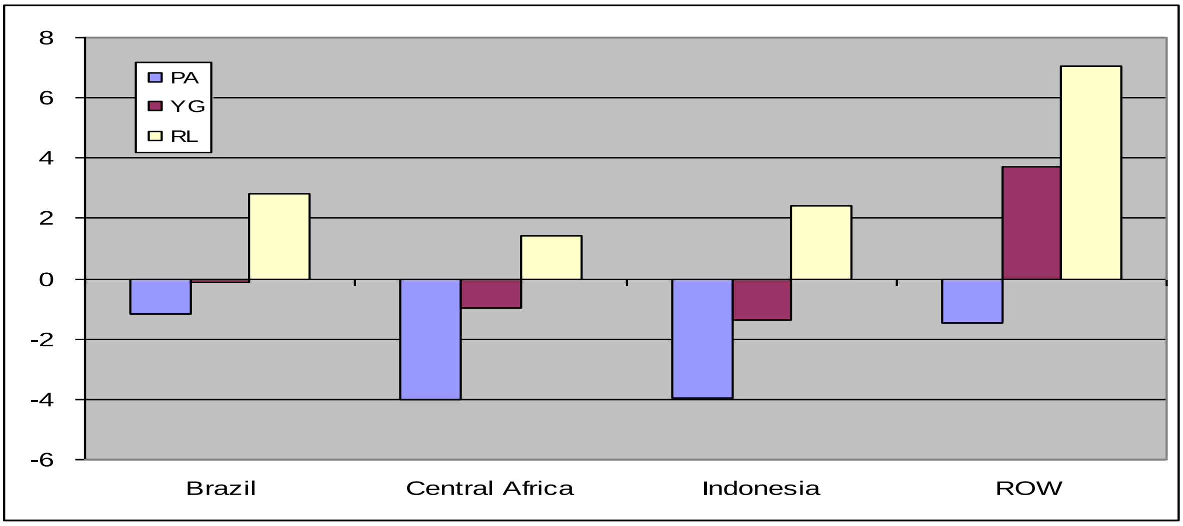

Figure 6. Consumer purchasing power of agri-food commodities growth in % compared with Baseline scenario in 2010-2030

9. Conclusions

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/regions analyzed.

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ANNEX 1: Areas suitable for agriculture

The NoFW area cap in Figure A1 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.

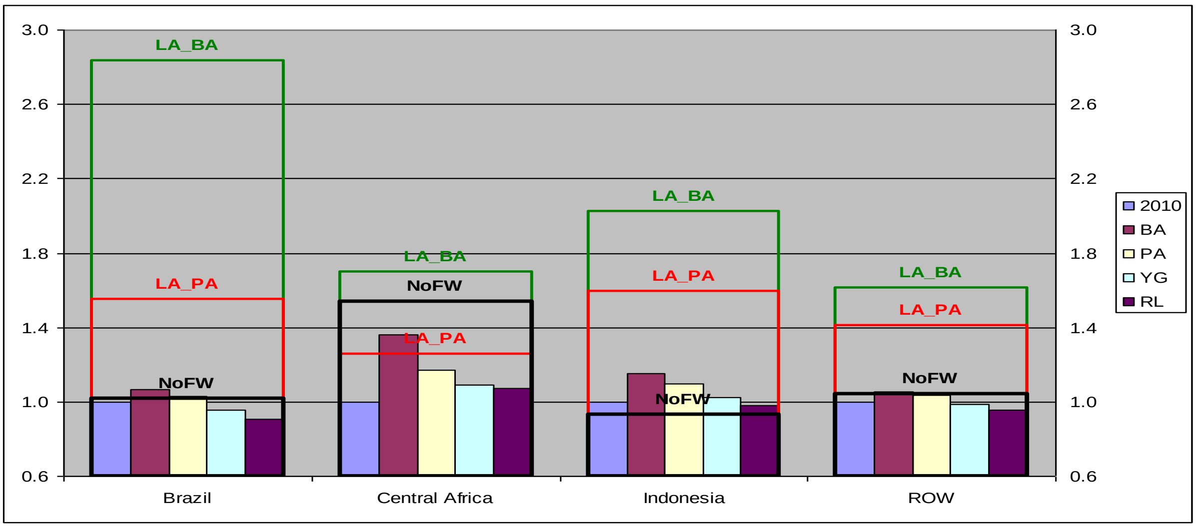

Figure A1. Areas suitable for agriculture under different scenarios