Development of the GTAP 7 Land Use Data Base

By

Misak Avetisyan
Uris Baldos
Thomas W. Hertel

GTAP Research Memorandum No. 19

Revised March 2011

Development of the GTAP Version 7 Land Use Data Base

By

Misak Avetisyan, Uris Baldos and Thomas W. Hertel

1. Background and Motivation

The land-use augmented version of the GTAP Data Base has been used for a wide variety of applications (T. W. Hertel, Rose, & Tol, 2009). It builds on global land cover and land use data bases documented in Monfreda et al. (2008) and Ramankutty and Foley (1999) as well as global forestry data developed by Sohngen and Tennity (2004). The methodology for integrating this information into the GTAP-AEZ framework is documented by Lee et al. (2009).

The underlying land use data were developed with a base year circa 2001 (The sub-national land use data varied in availability and spanned the period 1997-2003). The original GTAP-AEZ Data Base incorporated this information into the version 6 GTAP Data Base, with a benchmark year of 2001. Subsequently the GTAP Data Base (version 7) has been updated to 2004, and the version 8 data base will be released in 2011 with a base year of 2007. This memorandum documents how the land use data has been updated from 2001 to 2004 for use in the version 7 data base, by time series data on land cover developed by Navin Ramankutty and national production and harvested area data from the FAO. If a new version of the Monfreda et al. data base does not become available by 2011, this same approach could be used to update the land use data to the 2007 benchmark used in GTAP v.8.

2. Land Cover Data

The *land cover* data, available by land type, agro ecological zone (AEZ), and country for the year 2004 has been generated using the Global Cropland and Pasture Data by Navin Ramankutty from McGill University[1]. The spatial data set, which covers the period 1700-2007, is a beta release of the revised historical cropland data set of Ramankutty and Foley (1999). It consists of annual data on the fraction of cropland and pasture cover to total land cover in each grid cell. The resolution of the data is 0.5 degree in latitude by longitude
Data on built-up lands at 500m resolution for the period 2001-2002 was also used. This data is part of the Global Maps of Urban Extent from Satellite Data from the Center for Sustainability and the Global Environment (SAGE) at the University of Wisconsin-Madison (Schneider, Friedl, & Potere 2010, 2009)[2]. The built-up land cover data is aggregated to 0.5 degree resolution so that it can be incorporated with the data on cropland and pasture cover.

2.1 Global distribution and changes in cropland and pasture cover

[1] The data is available at http://www.geog.mcgill.ca/~nramankutty/Datasets/Datasets.html
[2] The data is available at http://sage.wisc.edu/people/schneider/research/data.html

Global maps on cropland, forests and pasture intensities for the year 2004, and the changes in intensities during the 2001-2004 period are provided in Figures 1 and 2. The upper panel reports the intensity of cropland cover at each pixel. Areas with the highest percentages of cropland cover are observed in North America, Brazil and Argentina, Europe and in Russia. In Africa, intense cropland cover is identified in the population dense region around Nigeria, as well as some parts of East Africa. In Asia, grid cells with high cropland intensities are clustered in South Asia (India, Pakistan and Bangladesh), Southeast Asia (Indonesia, Thailand and Vietnam), and in Northeastern China.
Forest cover intensities are displayed in the middle panel of Figure 1. The highest concentrations of forests in the Western Hemisphere are found in the Eastern U.S., Canada and in South America (Brazil, Peru, Colombia and Venezuela). Forest cover in Africa is clustered in Central Africa. In Asia, forests are concentrated in South East Asia, East Asia and China and Mongolia.

The lower panel of Figure 1 maps pasture land cover intensities. The highest concentrations of pasture in the Western Hemisphere are found in the Western U.S. and in South America (Brazil, Argentina, Colombia and Venezuela). Intense pasture cover in Africa is clustered in Eastern and Southern Africa. In Asia, pastures are concentrated in Central Asia, China and Mongolia. Australia also has areas with high pasture cover.

The upper, middle and lower panels of Figure 2 report changes in cropland, forest and pasture cover, respectively, over the 2001-2004 period. The Eastern US as well as the Great Plains of Canada generally show declines in cropland cover over this period. The same is true of Central and Eastern Europe and much of China. In contrast, Brazil shows strong increased in cropland cover intensity over this three year period. The same is true of much of the Guinea Savannah zone in Africa, parts of Western Europe, the Middle East and Southeast Asia.

Forest cover increased in the Eastern US while it decreased in Latin America and South America, particularly in Brazil (Figure 2, middle panel). In Europe, there are small areas of decreases in forest cover but most of the increase can be found in Eastern Europe. West Africa also experienced reductions in forest cover. In Asia, the declining forest cover is concentrated in South East Asia (Malaysia and Indonesia) while forests increased in East Asia.

Not surprisingly, since the total land area in each pixel is fixed in size, the pasture cover intensity changes tend to mirror the cropland cover changes (Figure 2, bottom panel). For example, much of the non-Amazon region in Brazil shows cropland expansion and pasture reduction. Pasture cover also shows expansion in much of the United States as well as Central and Eastern Europe.

Figure 1. Global distribution in 2004 and changes in distribution of cropland cover during 2001 to 2004

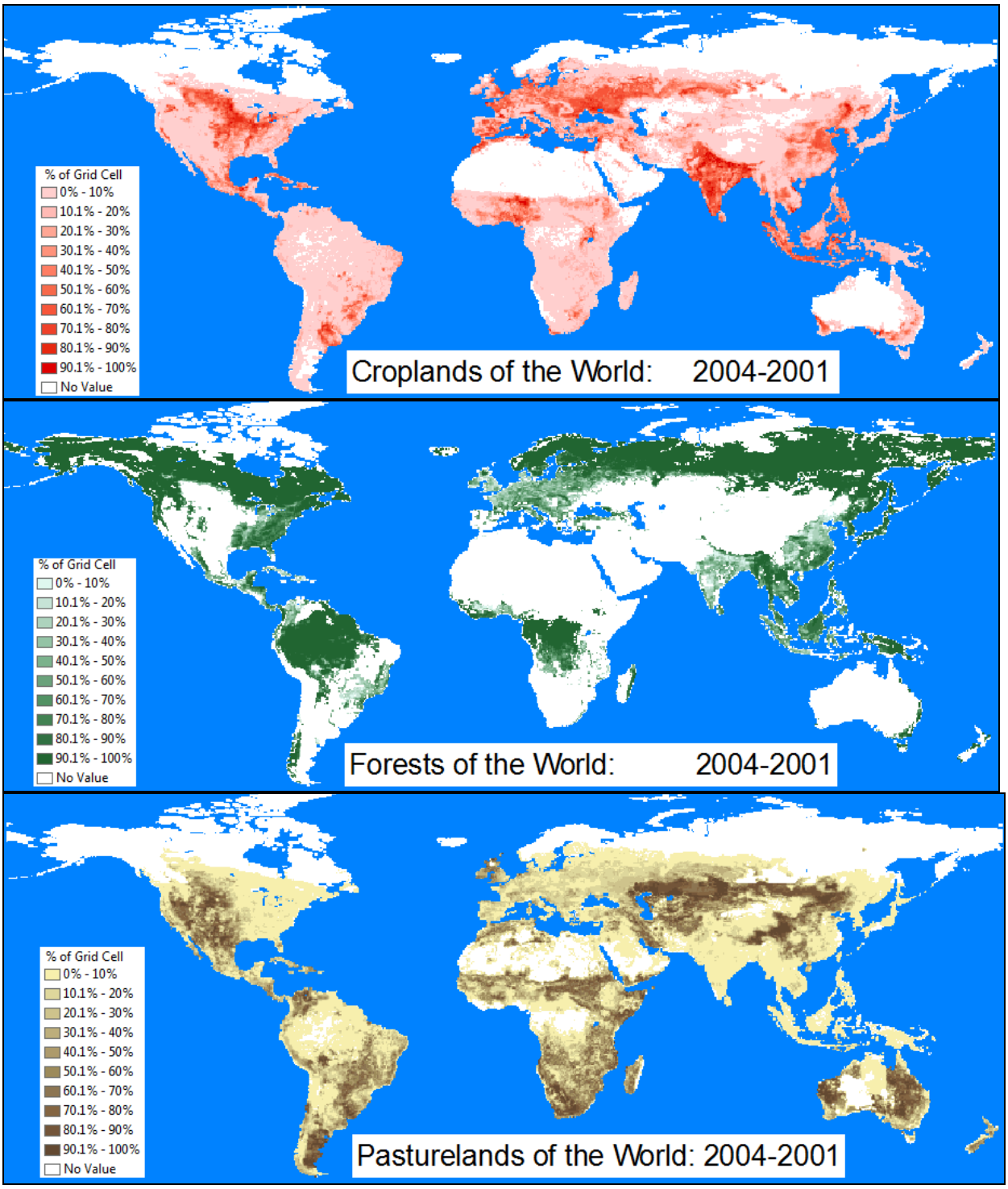
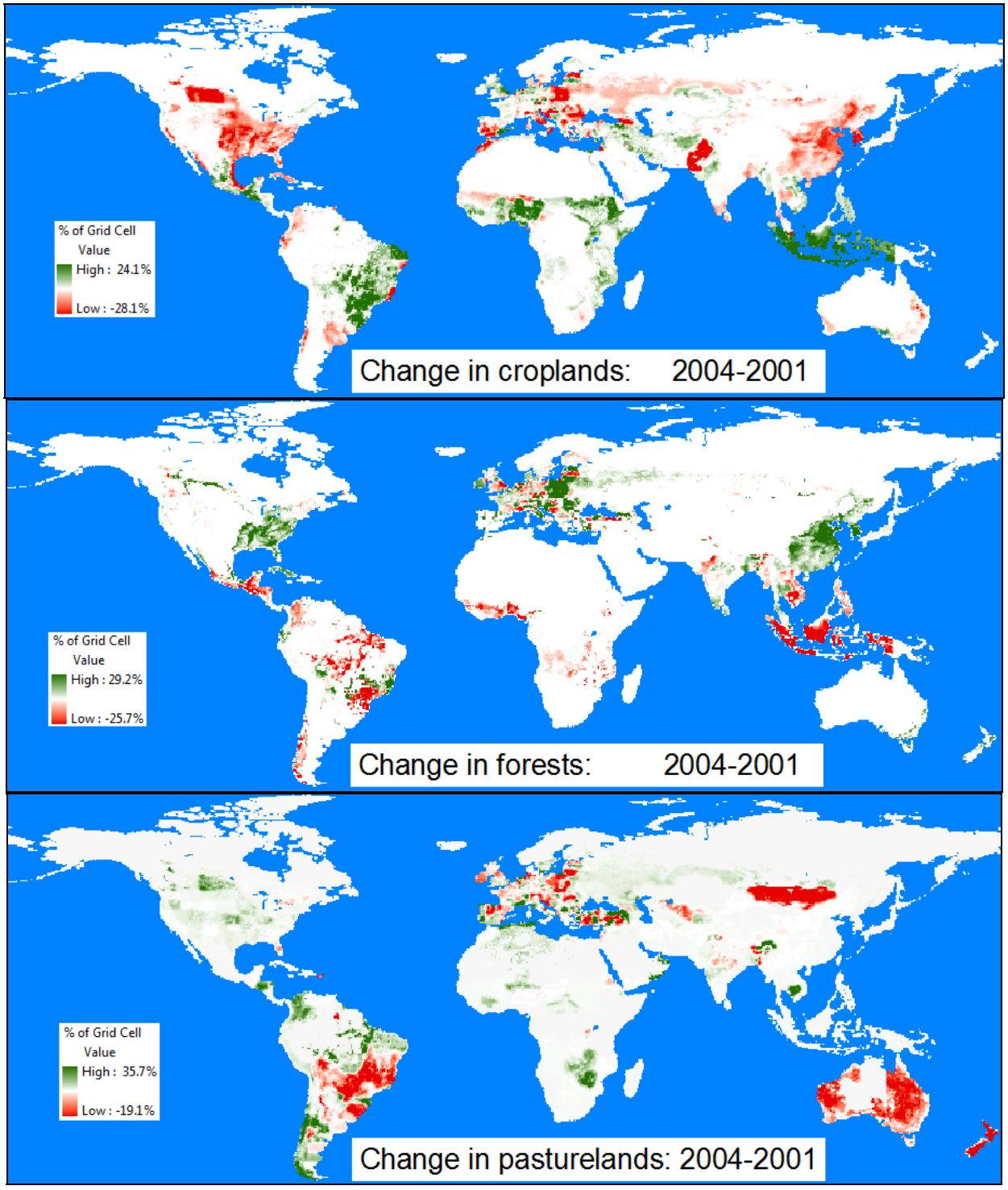


Figure 2. Global distribution in 2004 and changes in distribution of pasture cover during 2001 to 2004



2.2 Key assumptions and procedures in updating the land cover data

The assumptions and procedures outlined in this memorandum supersedes those mentioned in the initial release of the land cover data[3]. As noted earlier, only land cover data for croplands, pasturelands and built-up lands are available. Thus, the land cover spatial data for savanna and grasslands, forests, shrublands and other lands were first calculated. The complete land cover spatial data were then aggregated into Agro-Ecological Zones, the aggregated format, used in the GTAP version 7 Data Base. The following procedures were adapted in constructing the 2004 land cover database.

(1) *Aggregation and normalization of agriculture and built-up land cover* - Within each grid-cell, the percentage of land cover for croplands, pasturelands and built-up lands were added. It is assumed that the percentage of combined land cover in a grid-cell should not exceed 100%. Given this, grid-cells wherein the combined agriculture and built-up land cover exceed 100% were normalized to ensure that the sum of land cover for these cells is consistent with our assumption.

(2) *Derivation of the residual land cover and its allocation to other land cover types* - The residual land cover was calculated by deducting the normalized land cover for agricultural and built-up lands from grid-cells with uniform value of 100%. Thus, the sum of the residual land cover and the normalized land cover for agricultural lands and built-uplands within each grid cell add up to 100%. The residual land cover was then allocated to savanna and grasslands, forests, shrublands and other lands using the Global Maps of Potential Vegetation by Ramankutty and Foley (1999). This map shows the expected vegetation type that would occur in a given grid-cell in the absence of human activities.

(3) *Conversion of the fractional land cover data into actual area of land cover* - To derive the grid-cell level areas for the different land cover types, a global map of the surface area of the earth was used. This map has the same grid-cell resolution as the land cover data (0.5 degree) and was provided by Navin Ramankutty. Actual areas were derived by multiplying the fractional land cover data with the surface area map for each grid-cell.

(4) *Aggregation of cropland and pasture land areas by AEZ and by country* - The grid-cell level areas for different land cover types were aggregated by overlaying the land cover maps with a map of global AEZs and countries. This map was used by Lee et al. (2005) in constructing the initial GTAP Land Use Data Base[4].

(5) *Calculating accessible forest area by AEZ and by country* – To derive the accessible forest area by AEZ and by country, the aggregated forest data was weighted by the share of accessible forests in total forest area by AEZ and by country. These shares are based on the data on accessible forests by Sohngen, Tennity, Hnytka and Meeusen (2008).

[3] Details of the methods used in the initial land cover data for version 7 are outlined in Figure A.1 in the Appendix.
[4] The map is available at https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1900

Total areas summed across AEZs and countries for different land cover types are listed in Table 1. It is important to note that the grand total land area in version 7 is less than in version 6. This can be attributed to the differences in grid-cell resolution of the data used in the two versions. Land cover data in version 6 is based on a 5 minute resolution which is more detailed compared to the 0.5 degree resolution used in version 7. With version 7, land cover types which experienced increases in areas include, forests, savanna & grassland, shrubland, cropland and other lands. Pasturelands and built-up lands have less areas in the version 7 compared to version 6.

Table 1. Comparison of total area for different land cover

Land Cover Types (in thousand hectares)	Versions	
	V.7	V.6
Forest	1,678,148	1,656,377
Savanna & Grassland	1,424,756	1,383,181
Shrubland	930,578	906,928
Cropland	1,544,485	1,528,109
Pastureland	2,745,751	2,841,724
Built-upland	61,691	77,346
Other land	2,111,197	2,109,597
Total	10,496,605	10,503,262

The changes in global land cover, by AEZ, between versions 7 and 6 are illustrated in Figures 3 and 4. Most of the land cover changes are within AEZ4 to AEZ14 (Figure 3), with the largest absolute changes in AEZs 4-10. For these AEZs, global pasture land cover has declined in version 7. Notable increases in cropland cover are observed in AEZ2 to AEZ6. A closer look at the changes within selected countries is shown in Figure 4. Similar to Figure 3, there is an overall decline in pasture land cover in version 7. Brazil, China, Morocco, Russia, and South Africa show the largest absolute reductions in pasture land cover. In U.S., Canada, China and Russia, there is a decrease in cropland cover, but cropland cover rises strongly in Brazil and India.

Of course these absolute changes in land cover must be placed into proper context. The percentage changes in cropland, pasture and forest cover are reported in tables 1 and 2. Relative to total land cover, the changes in the shares of cropland and pasture cover by AEZ are generally small (Table 1). Table 2 reports the country-specific changes. Here, we see that the biggest proportional increases in cropland cover are in India and Morocco, followed by Brazil. Morocco shows a very sharp percentage reduction in pasture lands, followed by South Africa and China. Details of the cropland and pasture land cover are shown in Table A.1 in the Appendix.

Figure 3. Land cover changes by AEZs: land cover data in v.7 compared to v.6

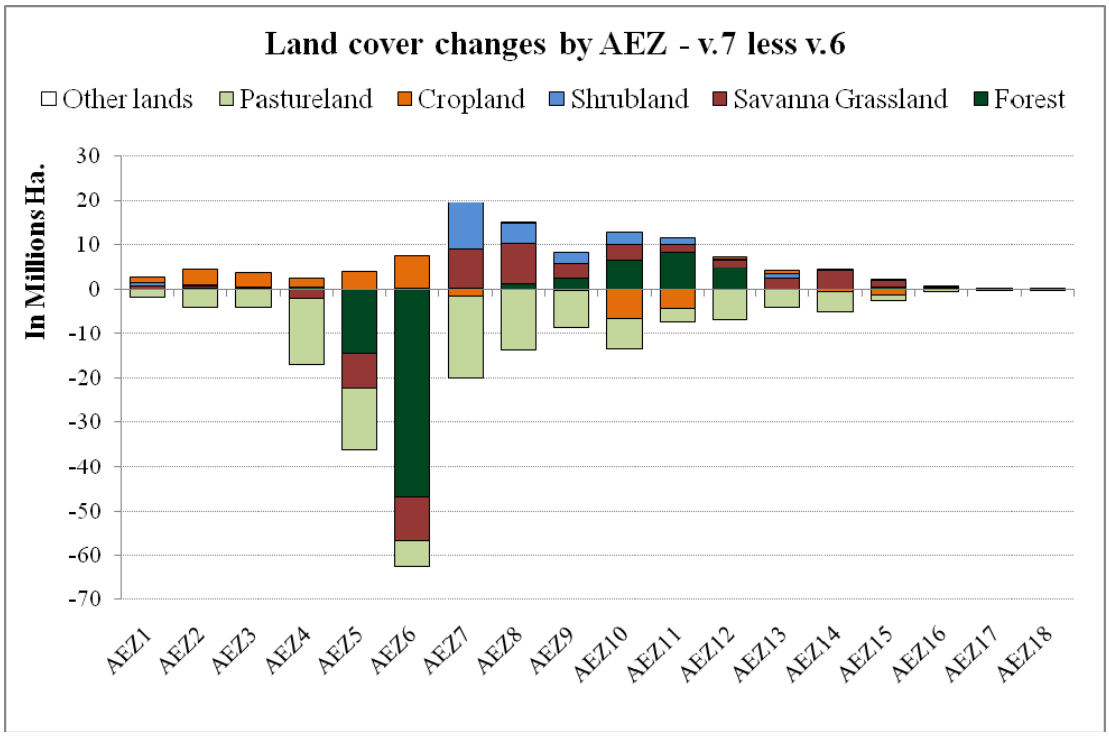


Figure 4. Land cover changes for selected countries: land cover data in v.7 compared to v.6

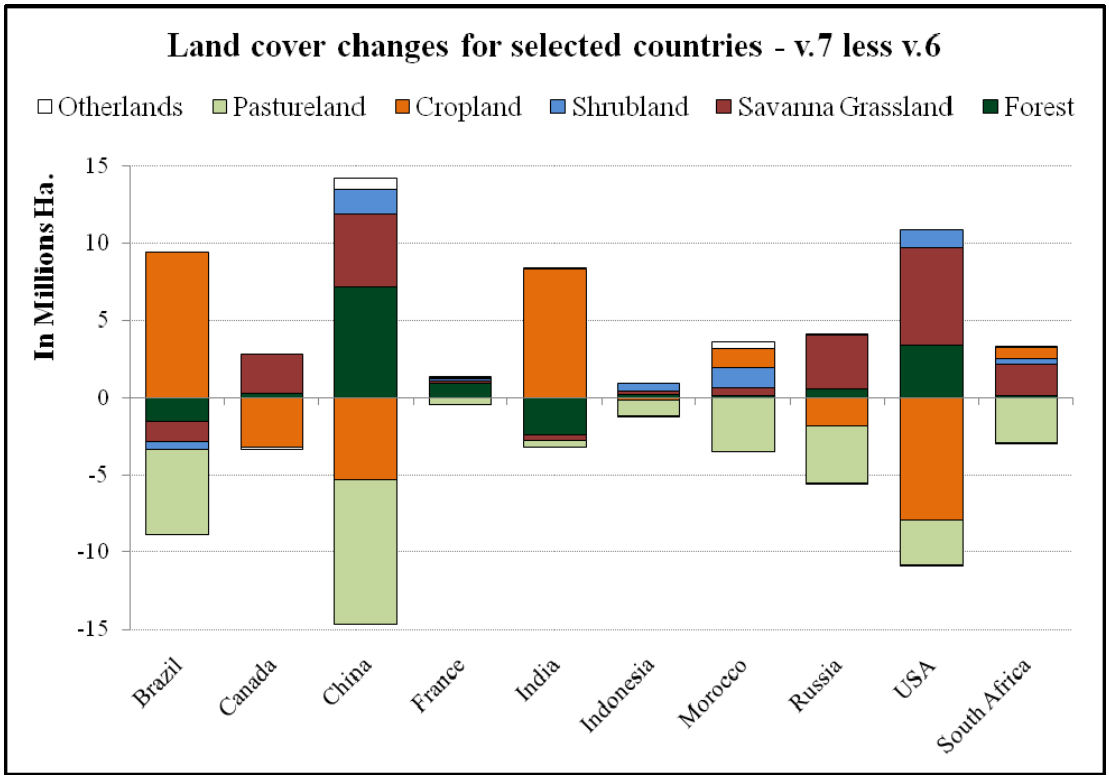


Table 1. Changes in the share of land cover to total land cover by AEZs

AEZ	Share of land cover to total land in selected AEZ (in %)						Differences in shares (V.7 less V.6)		
	Version 7			Version 6					
	Forest	Cropland	Pasture	Forest	Cropland	Pasture	Forest	Cropland	Pasture
AEZ1	0.07	2.79	21.76	0.07	2.67	21.96	0.00	0.12	-0.19
AEZ2	0.75	18.33	38.35	0.73	17.21	39.72	0.02	1.12	-1.38
AEZ3	2.88	24.62	28.00	2.84	23.90	28.78	0.04	0.72	-0.77
AEZ4	11.25	20.14	31.27	11.18	19.22	32.50	0.07	0.91	-1.23
AEZ5	24.35	18.22	29.71	24.47	17.02	30.94	-0.12	1.19	-1.23
AEZ6	53.97	20.45	15.39	54.70	19.20	16.10	-0.72	1.25	-0.71
AEZ7	0.30	4.48	33.10	0.29	4.55	33.88	0.00	-0.07	-0.78
AEZ8	3.51	26.04	40.50	3.36	26.01	42.44	0.15	0.03	-1.94
AEZ9	17.68	33.00	22.23	17.17	32.97	23.67	0.51	0.02	-1.44
AEZ10	33.51	33.90	17.31	32.39	34.71	18.25	1.12	-0.81	-0.94
AEZ11	34.54	29.21	19.81	32.11	30.16	20.52	2.42	-0.95	-0.71
AEZ12	34.21	22.59	27.64	32.84	22.34	29.11	1.38	0.25	-1.46
AEZ13	2.20	4.74	24.93	2.19	4.63	25.60	0.00	0.10	-0.68
AEZ14	26.10	2.19	12.69	26.11	2.24	13.27	-0.01	-0.05	-0.58
AEZ15	56.85	7.68	14.76	56.59	7.96	15.04	0.26	-0.28	-0.28
AEZ16	26.76	4.79	34.50	26.58	5.10	35.16	0.18	-0.31	-0.66
AEZ17	39.04	0.75	20.51	39.79	0.79	20.15	-0.75	-0.04	0.37
AEZ18	0.00	0.85	99.02	0.00	1.02	98.98	0.00	-0.17	0.04

Table 2. Changes in the share of land cover to total land cover by country

Country	Share of land cover to total land in selected country (in %)						Differences in shares (V.7 less V.6)		
	Version 7			Version 6					
	Forest	Cropland	Pasture	Forest	Cropland	Pasture	Forest	Cropland	Pasture
Brazil	28.03	10.91	31.53	28.43	9.26	32.65	-0.39	1.65	-1.12
Canada	22.15	8.73	4.49	22.06	9.42	4.49	0.09	-0.69	0.01
China	15.85	15.49	30.52	15.03	16.03	31.47	0.83	-0.54	-0.95
France	34.18	39.33	20.13	32.26	38.87	20.98	1.92	0.46	-0.85
India	30.00	60.23	1.98	34.19	55.28	2.49	-4.19	4.95	-0.51
Indonesia	7.30	70.04	4.42	7.20	69.95	4.81	0.10	0.09	-0.39
Morocco	0.29	21.06	35.00	0.00	18.33	43.02	0.29	2.73	-8.02
Russia	33.39	15.56	9.82	33.20	15.74	10.25	0.19	-0.17	-0.43
USA	28.67	22.03	28.68	28.21	22.99	29.00	0.47	-0.96	-0.32
South Africa	1.42	12.39	59.92	1.33	11.84	62.30	0.08	0.55	-2.38

3. Data on Crop Production and Area

The new version of the GTAP Land Use Data Base has been developed using the Food and Agriculture Organization of the United Nations (FAO) 2004 data on *production*, *harvested area* and *price*, available by country and 159 FAO crop categories. The data can be downloaded from the FAOSTAT website (http://faostat.fao.org/). It should be noted that GTAP version 6 uses data from Monfreda et al. (2008) which covers around 175 crops. To fix this discrepancy, we assume that the production and harvested area data for certain crops are the same in both versions 6 and 7 (see Table A.3 in the Appendix). Tables 3 and 4 show the production and harvested areas, for the years 2004 and 2001, for selected crops and countries.

In general, the global production and harvested areas of major crops are higher in 2004 (Table 3). Significant growth in global production is observed for rapeseed (+27%), soybeans (+23%), maize (+19%) and millet (+19%). For sugarcane, the increase in global production is modest (+5%) while there is a slight reduction for paddy rice (-1%). Since production is a function of harvested area, it is hardly surprising that most crops also experienced increases in the global harvested areas. The largest increases were for millet (+10%), sorghum (+15%) and soybeans (+22%). There is a decline in the global harvested areas for paddy rice (-4%) during the 2001-2004 period.

Table 3. Global production and harvested area of major crops

Crops	Production (in million tonnes)			Harvested Area (in million hectares)		
	2001	2004	% change	2001	2004	% change
Barley	136.1	153.8	13%	53.9	57.5	7%
Maize	612.1	728.8	19%	137.4	147.5	7%
Millet	25	29.6	19%	31.1	34.1	10%
Paddy Rice	611.8	607.8	-1%	156.4	150.5	-4%
Sorghum	52.4	57.9	10%	35.3	40.5	15%
Wheat	572.9	632.7	10%	208	216.9	4%
Rapeseed	36.6	46.5	27%	24.2	25.3	5%
Soybeans	166.9	205.5	23%	74.9	91.6	22%
Sugarcane	1,278.2	1341.1	5%	19.7	20.3	3%

Viewed at a national level, there were notable changes in the production of major agricultural crops during the 2001-2004 period in Brazil, China, India and the U.S. (Table 4). Soybean and sugarcane production in Brazil rose by around 15.3 million tonnes (Mt) and 62.5 Mt, respectively. In China, maize production grew by 11.1 Mt while the production of paddy rice and wheat fell by 18.6 Mt and 11.0 Mt, respectively. Sugarcane production in India decreased by around 53.2 Mt. In Russia, wheat production increased by 8.9 Mt. U.S. maize and soybean production grew by 49.3 Mt and 9.0 Mt, respectively.

Significant increases in harvested areas are observed in Brazil and Russia while major decreases are seen in the U.S., Canada and China (Table 4). Harvested areas in Brazil for maize, wheat and soybean rose by around 1.1 million hectares (Mha), 1.2 Mha, and 7.6 Mha, respectively. In Russia, there is an increase of around 3.3 Mha in the harvested area for wheat. Canada and the U.S. both experienced reductions in the harvested area for wheat (1.3 Mha and 2.3 Mha,

respectively). In China, harvested areas of paddy rice and wheat fell by around 3.6 Mha and 5.1 Mha. The harvested area in India for paddy rice and soybeans decreased by 2.3 Mha and increased by 1.4 Mha, respectively.

Table 4. National production and harvested area of major crops for selected countries

			Brazil	Canada	China	France	Indonesia	India	Morocco	Russia	USA	S. Africa
Harvested Area (in thousand hectares)	2001	Barley	132	4324	1079	1567	0	726	2099	9004	2052	74
		Maize	11348	1270	24900	1734	3145	6516	284	588	29758	3105
		Millet	0	0	1225	0	0	12280	0	720	164	4
		Paddy Rice	2958	0	32253	21	11837	44218	6	152	1333	0
		Sorghum	394	0	891	54	0	9674	23	0	3369	115
		Wheat	1632	10708	26746	4926	0	26201	2677	19672	22550	918
		Rapeseed	0	4778	7354	1071	0	5552	0	15	475	0
		Soybeans	13685	1096	8979	89	694	6196	0	330	30088	95
		Sugarcane	5027	0	1378	0	339	4257	16	0	440	327
	2004	Barley	142	3841	786	1631	0	657	2324	9562	1627	83
		Maize	12411	1072	25467	1821	3357	7430	245	870	29798	3204
		Millet	0	0	916	4	0	11886	6	935	241	21
		Paddy Rice	3733	0	28616	20	11923	41907	4	125	1346	1
		Sorghum	931	0	570	48	0	9331	18	26	2637	130
		Wheat	2807	9389	21626	5237	0	26595	3064	22920	20222	830
		Rapeseed	34	4867	7272	1125	0	5428	1	232	338	44
		Soybeans	21539	1174	9582	59	565	7571	1	555	29930	135
		Sugarcane	5632	0	1393	0	345	3938	13	0	380	325
Production (in thousand tonnes)	2001	Barley	277	12150	3209	9606	0	1443	1506	15562	6465	137
		Maize	34899	9212	119371	14866	9049	11836	159	1445	250590	8085
		Millet	0	0	2213	0	0	9970	0	701	236	2
		Paddy Rice	9227	0	199085	119	51799	130668	27	487	9235	0
		Sorghum	729	0	3132	314	0	7526	14	0	12980	286
		Wheat	2931	23629	102943	34220	0	70412	2999	36465	62097	2146
		Rapeseed	0	6697	10971	3346	0	5044	0	13	712	0
		Soybeans	34246	2612	15591	225	863	6048	0	321	76009	148
		Sugarcane	352739	0	94739	0	22958	287092	1128	1	34353	23000
	2004	Barley	397	12557	3222	11032	0	1298	2760	17180	6091	185
		Maize	41788	8837	130434	16372	11225	14172	224	3516	299914	9710
		Millet	0	0	1813	20	0	10841	8	1117	342	12
		Paddy Rice	13277	0	180523	115	54088	124697	30	471	10540	3
		Sorghum	2159	0	2341	257	0	6681	15	44	11523	373
		Wheat	5819	24796	91952	39693	0	72156	5540	45413	58738	1687
		Rapeseed	57	7674	13182	3993	0	6291	1	276	613	32
		Soybeans	49550	3044	17404	147	723	6876	1	555	85013	220
		Sugarcane	415206	0	91044	0	26750	233862	872	0	26320	19095

4. Development of the AEZ Land Rental Data Base

The further processing of the FAO data involves introduction of AEZs. The AEZ shares for harvested area and production are not available for 2004. Accordingly, these are computed from the GTAP version 6 land use data and assumed to be unchanging over the 2001-2004 period. In other words, if maize production rose in the US over this period, it is assumed to rise in all regions by the same proportion. Accordingly, we have the following relationships:

$$HARVESTAREA_{r,a,b} = HARVESTAREA_{r,b,2004}^{Version7FAO} * \frac{HARVESTAREA_{r,a,b}^{Version6}}{\sum_{m \in AEZ18} HARVESTAREA_{r,m,b}^{Version6}} \quad (1)$$

$$PRODUCTION_{r,a,b} = PRODUCTION_{r,b,2004}^{Version7FAO} * \frac{PRODUCTION_{r,a,b}^{Version6}}{\sum_{m \in AEZ18} PRODUCTION_{r,m,b}^{Version6}} \quad (2)$$

where:

r denotes the region;
a denotes the AEZ;
b denotes the crop;

For special cases when we observe non-zero harvested area (production) for some crops in FAO data base but zero AEZ shares in the GTAP version 6 (2001) land use data, we apply cropland cover AEZ shares.

$$\begin{aligned} HARVESTAREA_{r,a,b} = IF\,(&LANDCOVER_{Cropland,a,r}^{Version7} \geq 0 \quad and \quad HARVESTAREA_{r,b,2004}^{Version7FAO} \geq 0 \\ &and \sum_{m \in AEZ18} HARVESTAREA_{r,m,b}^{Version6} = 0) \\ &THEN\,(HARVESTAREA_{r,b,2004}^{Version7FAO} * LANDCOVSHARE_{Cropland,a,r}^{Version7}) \end{aligned} \quad (3)$$

$$\begin{aligned} PRODUCTION_{r,a,b} = IF\,(&HARVESTAREA_{r,a,b} \geq 0 \quad and \quad PRODUCTION_{r,b,2004}^{Version7FAO} \geq 0 \\ &and \sum_{m \in AEZ18} PRODUCTION_{r,m,b}^{Version6} = 0) \\ &THEN\,(PRODUCTION_{r,b,2004}^{Version7FAO} * LANDCOVSHARE_{Cropland,a,r}^{Version7}) \end{aligned} \quad (4)$$

where *LANDCOVSHARE* denotes the land cover (cropland) AEZ share.

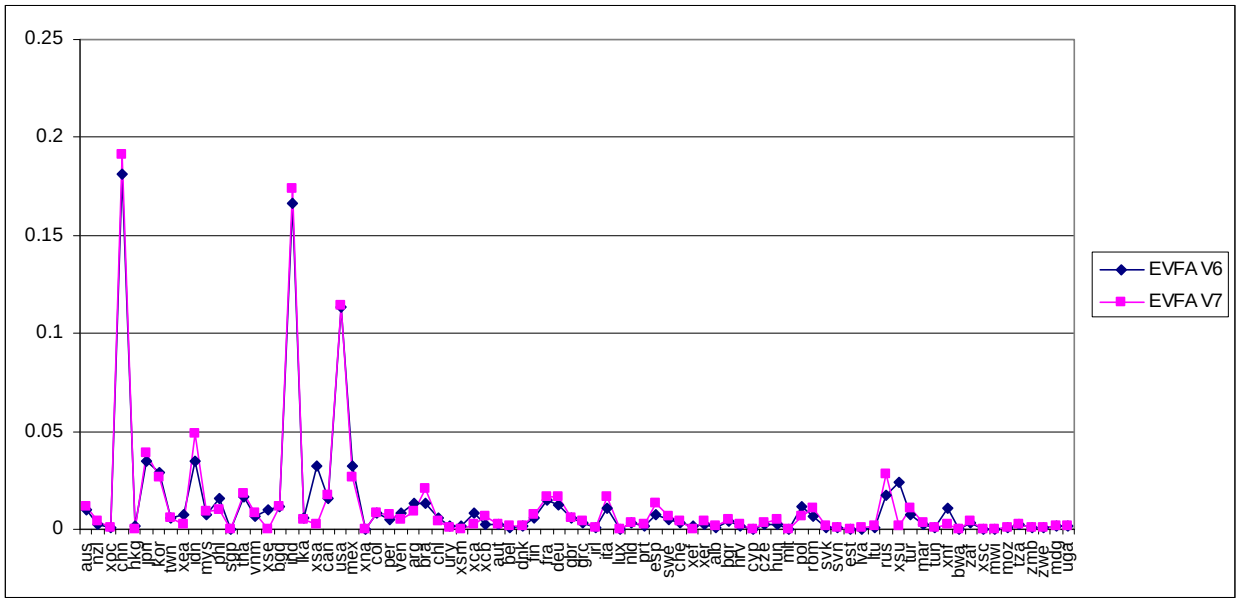
There is no need for further treatment of the land cover data, since it is already available by AEZ.

To compute the forest land area we use the GTAP version 6 forest land cover (accessible forest land area) to share out the GTAP version 7 forest land across tree species, vintage, and management types. Thus we assume, as with crop production, that the regional composition of national forests does not change over this three year period.

5. Changes in the Land Use Data Base

We compare the GTAP version 7 Land Use Data Base with the version 6 to observe the main changes in the new land use data. In particular, to compare the changes in shares of total land rents by region we choose 82 regions (Appendix – Table A.2), which are common for the two versions of the land use data. As we can see from Figure 5, there are increases in total land rents in most regions in the version 7 land use data set, as expected due to increasing productivity as well as rising scarcity of land with economic growth.

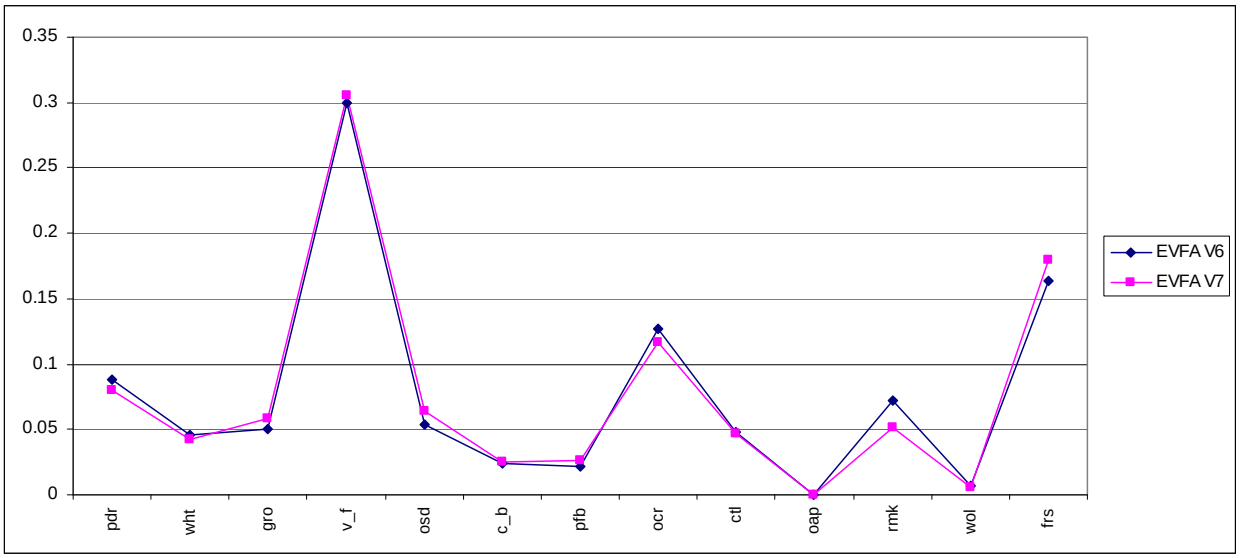
Figure 5. Changes in shares of total land rents by region



A similar pattern can be observed in comparing the changes in shares of total land rents by sector, as shown in Figure 6. In particular:

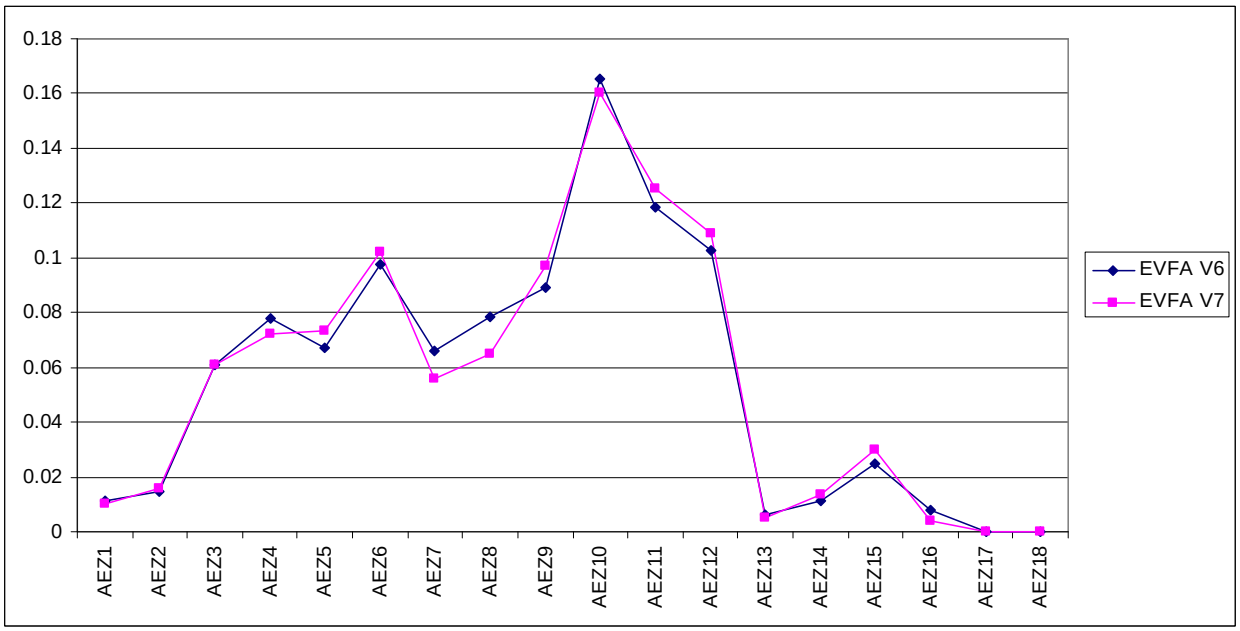
1. Production of paddy rice ("pdr") falls from 611,846,208 tones (version 6) to 607,725,696 tones (version 7), thus we see decline in paddy rice land rents.
2. Crops that are mapped to "gro", "v_f", and "osd" sectors show increased production and therefore increased land rents.
3. The total area of pasture land decreases from 2.84 billion hectares to 2.75 billion hectares resulting in lower land rents for "rmk" sector in the version 7 land use data set.

Figure 6. Changes in shares of total land rents by sector



The comparison of two data sets by AEZs shows that the shares of total land rents in version 7 land use data are decreasing in the tropical and temperate AEZs 1-12 (Figure 7). Recall that we introduced AEZs to FAO production and harvested area data sets by applying the corresponding AEZ shares from the version 6 land use data. Moreover, we used cropland AEZ shares for some crops in countries with non-zero production (harvested area) in FAO data base but having zero AEZ shares in the version 6 land use data. This is the main reason for the aforementioned changes in AEZ shares of total land rents in the version 7 land use data set.

Figure 7. Changes in shares of total land rents by AEZ



Since in the version 7 land rent computations were using the same assumptions as in version 6, the shares of land rents by AEZs for individual crops, which are not aggregated in the final data base, show strong agreement with those from version 6. But this is not the case for aggregated crop categories, as expected. For instance, wheat ("wht") is not aggregated under any category, thus its land rental shares by AEZs do not demonstrate significant variations both in individual regions, such as the U.S., (Figure 8) and also globally (Figure 9).

Figure 8. Changes in shares of wheat land rents by AEZ in the US

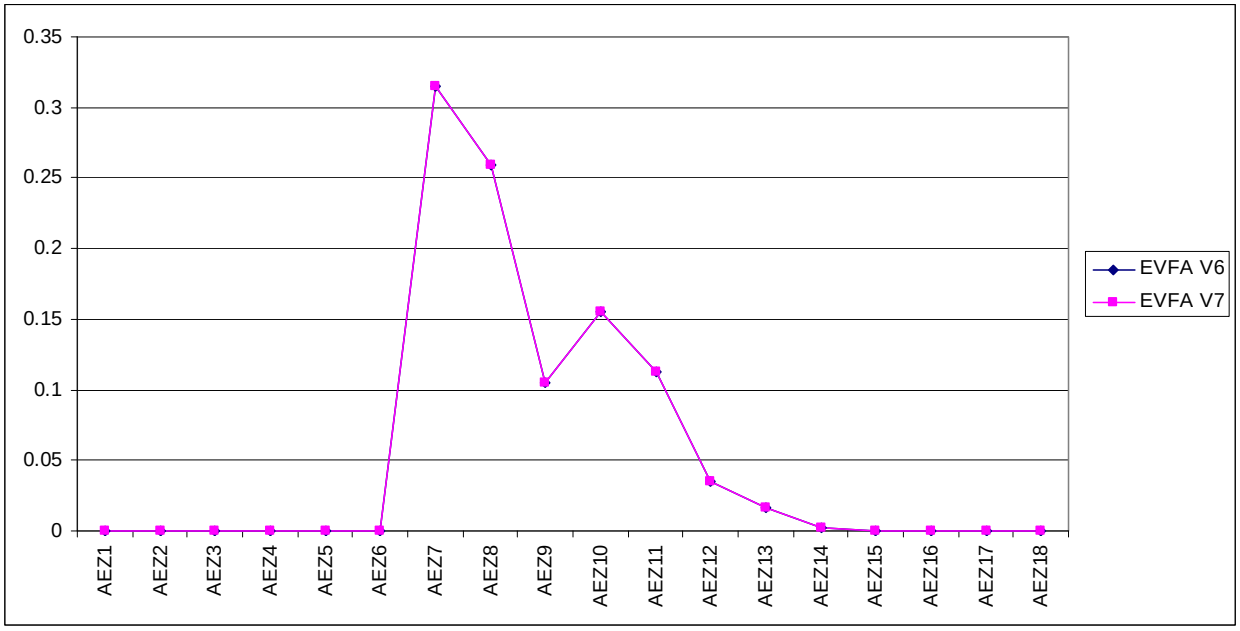
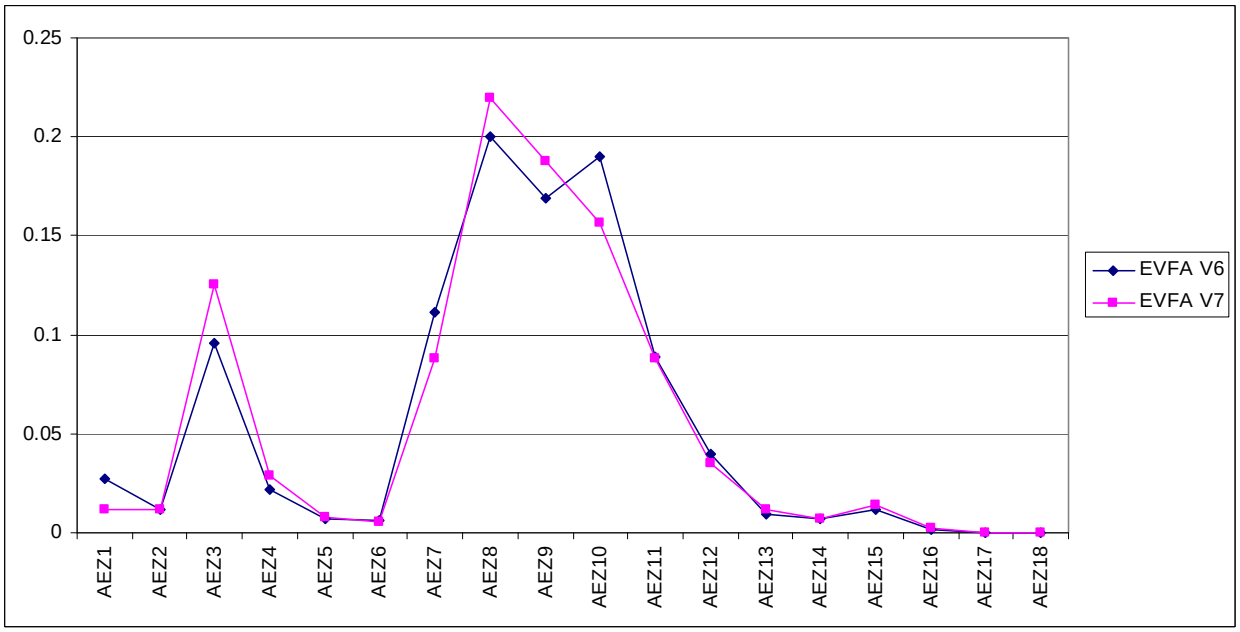


Figure 9. Changes in shares of global wheat land rents by AEZ



In case of aggregated crop categories, such as oil seeds ("osd"), we see relatively large differences. For example, in the US land rental shares for oil seeds show slight disparity, as shown in Figure 10. Globally, we can see even larger variations due to the compositional nature of the oil seeds sector (Figure 11).

Figure 10. Changes in shares of oil seeds land rents by AEZ in the US

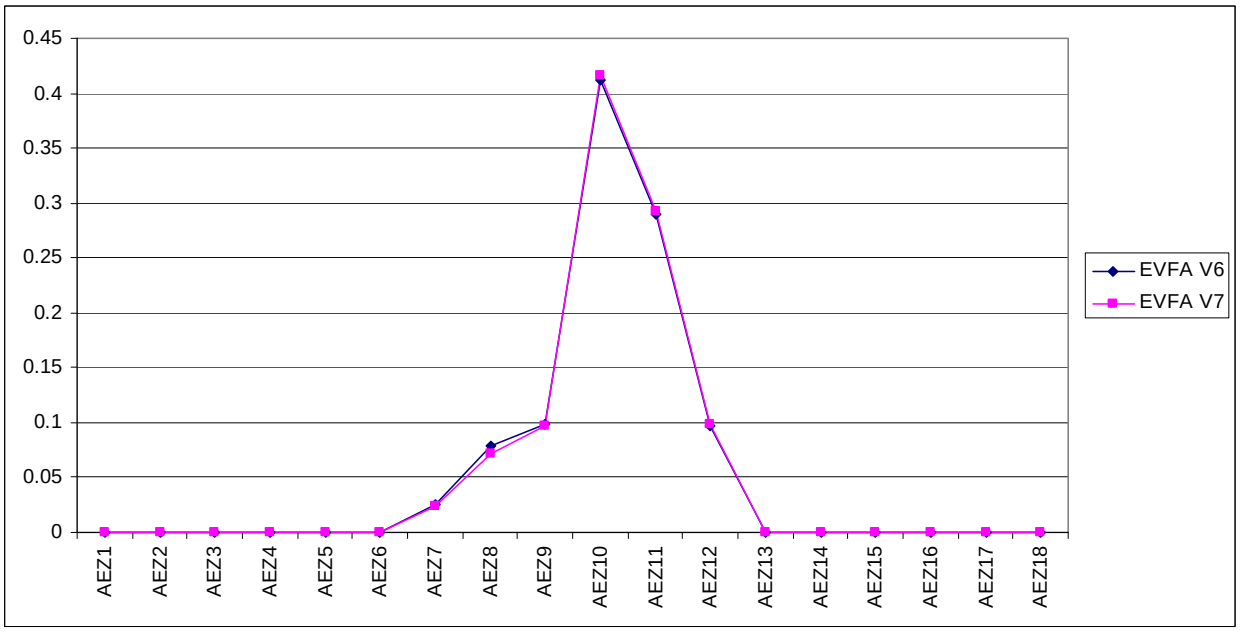
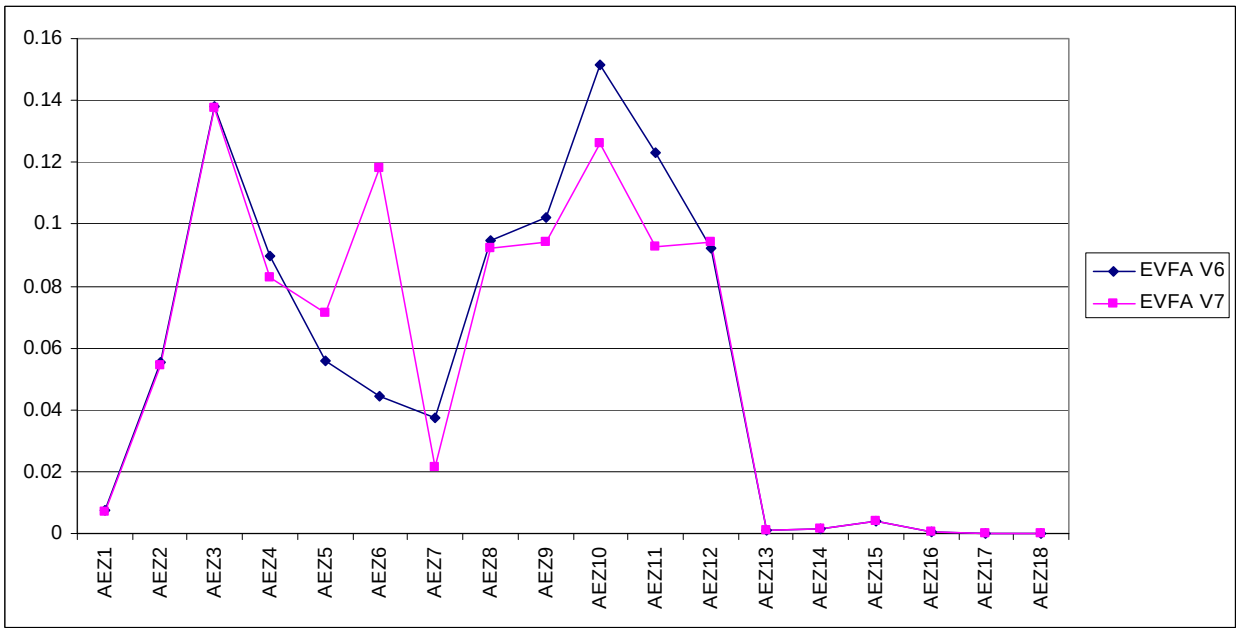


Figure 11. Changes in shares of global oil seeds land rents by AEZ



References

Hertel, T. W., Rose, S., & Tol, R. (2009). Land Use In Computable General Equilibrium Models: An Overview. In *Economic Analysis of Land Use in Global Climate Change Policy*, Routledge Explorations in Environmental Economics. United Kingdom: Routledge.

Lee, H., Hertel, T., Rose, S., & Avetisyan, M. (2009). Economic Analysis of Land Use in Global Climate Change Policy. In *An Integrated Land Use Data Base for CGE Analysis of Climate Policy Options* (pp. 72-88). Abingdon, UK: Routledge Press.

Lee, H., Hertel, T. W., Sohngen, B., & Ramankutty, N. (2005). *Towards An Integrated Land Use Data Base for Assessing the Potential for Greenhouse Gas Mitigation* (No. 25). GTAP Technical Paper (p. 83). IN, USA: Center for Global Trade Analysis, Dept. of Agricultural Economics, Purdue University.

Monfreda, C., Ramankutty, N., & Foley, J. A. (2008). Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Global Biogeochemical Cycles*, *22*, 19 PP. doi:200810.1029/2007GB002947

Ramankutty, N., & Foley, J. A. (1999). Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochemical Cycles*, *13*(4), PP. 997-1027. doi:199910.1029/1999GB900046

Schneider, A., Friedl, M. A., & Potere, D. (2009). A new map of global urban extent from MODIS satellite data. *Environmental Research Letters*, *4*(4), 044003. doi:10.1088/1748-9326/4/4/044003

Schneider, A., Friedl, M. A., & Potere, D. (2010). Mapping global urban areas using MODIS 500-m data: New methods and datasets based on [`]urban ecoregions'. *Remote Sensing of Environment*, *114*(8), 1733-1746. doi:10.1016/j.rse.2010.03.003

Sohngen, B., & Tennity, C. (2004). *Country Specific Global Forest Data Set V.1.* (memo). Columbus, OH , USA: Department of Agricultural, Environmental, and Development Economics, Ohio State University.

Sohngen, B., Tennity, C., Hnytka, M., & Meeusen, K. (2008). *Global Forestry Data for the Economic Modeling of Land Use*. Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University. Retrieved from http://ideas.repec.org/p/gta/workpp/2602.html

Appendix: Supplementary Tables and Figures

Table A.1. Comparison of land cover across AEZs between version 6 and 7

Agro-ecological zones	GTAP v.6 (in thousand hectares)							
	1 Forest	**2 SavnGrasslnd**	**3 Shrubland**	**4 Cropland**	**5 Pastureland**	**6 Builtupland**	**7 Otherland**	**Total**
AEZ1	681.7	36709.6	147477.7	25023.5	205761.3	1774.6	519693.8	937122.2
AEZ2	2212.3	76132.8	48073.3	51973.1	119959.6	732.8	2909.5	301993.5
AEZ3	13610.6	167484.3	43441.1	114560.9	137905.3	1852.7	385.3	479240.1
AEZ4	66197.9	191122.5	26310.7	113804.1	192445.5	2182.7	0.0	592063.5
AEZ5	156800.0	165959.5	8475.8	109105.8	198311.1	2212.7	0.0	640864.9
AEZ6	346266.5	57585.5	2948.8	121563.8	101924.6	2771.3	0.0	633060.5
AEZ7	6856.0	171701.2	458575.0	107265.9	798324.1	5160.8	808326.8	2356209.8
AEZ8	23748.9	114066.2	62202.1	183735.0	299780.4	7501.5	15372.3	706406.4
AEZ9	91546.8	84748.0	43581.7	175786.7	126172.6	7733.4	3524.1	533093.2
AEZ10	221827.0	54129.6	28556.0	237696.4	124993.6	16288.9	1288.4	684779.9
AEZ11	120157.7	34755.2	12942.6	112851.6	76764.3	16470.9	219.5	374161.8
AEZ12	137178.8	52406.6	2546.5	93326.0	121601.9	10524.2	192.2	417776.1
AEZ13	13151.6	41526.8	15050.2	27761.9	153425.2	261.4	348031.2	599208.2
AEZ14	200373.2	65159.1	2991.9	17211.1	101853.5	282.9	379654.3	767526.0
AEZ15	240876.4	56136.1	1439.5	33870.2	64027.8	1547.1	27781.4	425678.5
AEZ16	13212.5	11900.6	2315.1	2537.7	17480.7	48.5	2218.7	49713.8
AEZ17	1678.9	1657.3	0.0	33.5	850.1	0.0	0.0	4219.9
AEZ18	0.0	0.0	0.0	1.5	142.5	0.0	0.0	144.0
Total	1656376.9	1383181.0	906928.0	1528108.6	2841724.1	77346.3	2109597.4	10503262.3
Agro-ecological zones	GTAP v.7 (in thousand hectares)							
	1 Forest	**2 SavnGrasslnd**	**3 Shrubland**	**4 Cropland**	**5 Pastureland**	**6 Builtupland**	**7 Otherland**	**Total**
AEZ1	685.8	37238.4	148378.6	26105.5	203931.4	1110.6	519638.2	937088.5
AEZ2	2270.4	76742.7	48323.3	55351.6	115775.9	532.2	2932.0	301928.2
AEZ3	13775.2	167613.1	43249.5	117889.0	134087.5	1824.6	390.0	478828.9
AEZ4	66571.1	192725.9	26237.1	119137.8	185034.7	1972.2	0.0	591678.7
AEZ5	156338.8	166589.2	8461.6	116983.8	190791.1	2996.6	0.0	642161.2
AEZ6	344252.8	58111.2	3033.8	130427.5	98135.6	3871.1	0.0	637832.1
AEZ7	6962.5	180714.5	468942.5	105615.6	779957.8	4380.4	809611.1	2356184.4
AEZ8	24771.1	123454.7	66630.9	183869.3	285984.3	5672.1	15766.8	706149.2
AEZ9	93954.6	88288.0	46066.6	175327.2	118117.3	5902.0	3658.0	531313.7
AEZ10	228546.3	57549.8	31293.1	231203.9	118085.9	14034.3	1286.6	681999.9
AEZ11	128432.5	36690.1	14241.8	108637.4	73657.4	9984.9	213.0	371857.0
AEZ12	142021.8	54234.6	2723.5	93767.6	114740.5	7392.5	207.0	415087.5
AEZ13	13161.5	43967.8	16078.7	28379.3	149324.7	279.0	347869.7	599060.6
AEZ14	200203.7	69282.0	3132.6	16786.6	97357.4	494.7	379768.7	767025.7
AEZ15	241271.3	57601.9	1462.2	32593.4	62628.0	1146.6	27703.2	424406.6
AEZ16	13274.1	12271.5	2322.0	2376.1	17112.7	95.4	2152.4	49604.1
AEZ17	1654.6	1681.1	0.0	31.8	869.4	1.3	0.0	4238.3
AEZ18	0.0	0.0	0.0	1.4	158.8	0.2	0.0	160.4
Total	1678148.0	1424756.4	930577.7	1544484.8	2745750.4	61690.6	2111196.8	10496604.7

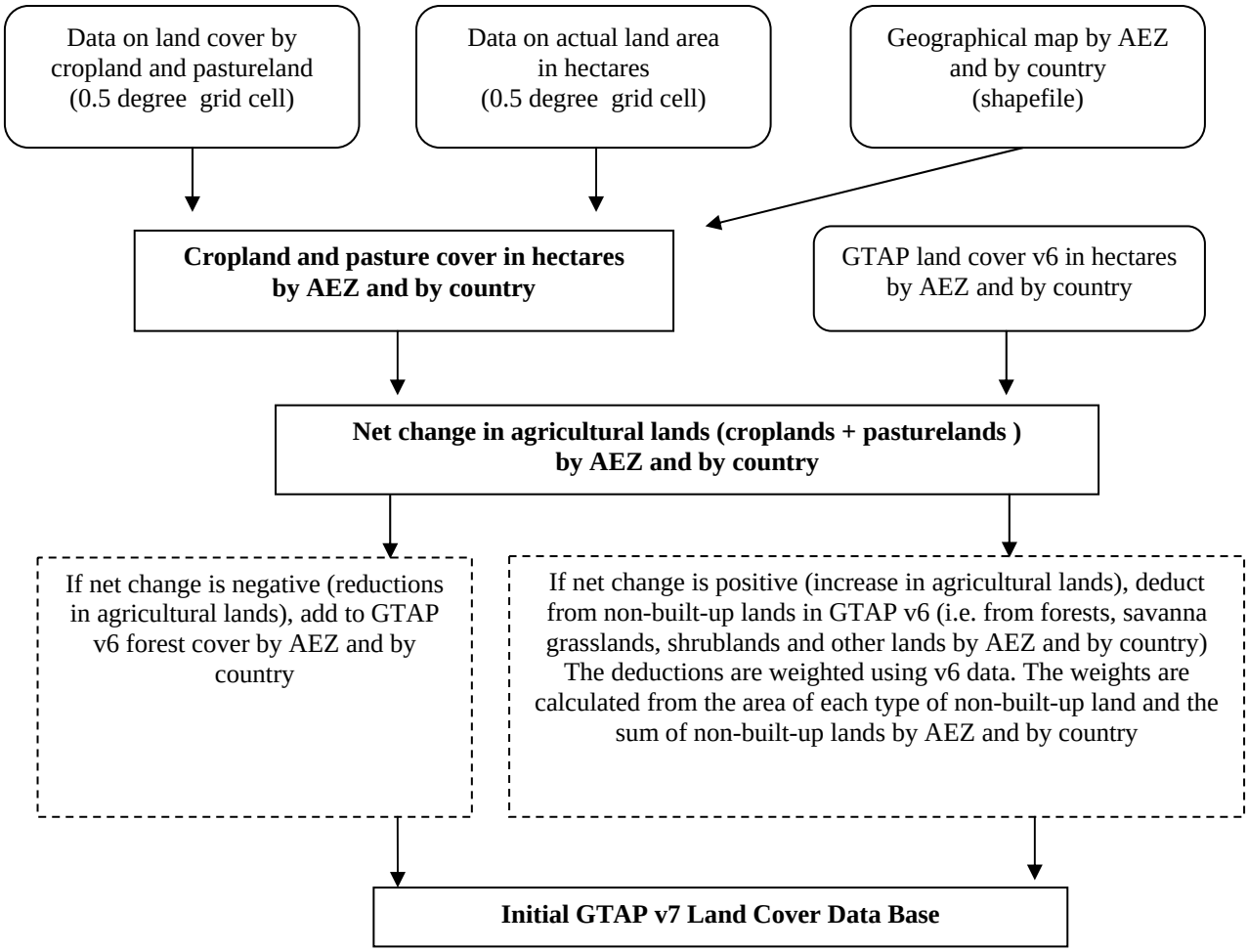
Table A.2. Regions used in Figure 5 comparisons

1	Australia
2	New Zealand
3	Rest of Oceania
4	China
5	Hong Kong
6	Japan
7	Korea
8	Taiwan
9	Rest of East Asia
10	Indonesia
11	Malaysia
12	Philippines
13	Singapore
14	Thailand
15	Vietnam
16	Rest of Southeast Asia
17	Bangladesh
18	India
19	Sri Lanka
20	Rest of South Asia
21	Canada
22	United States
23	Mexico
24	Rest of North America
25	Colombia
26	Peru
27	Venezuela
28	Argentina
29	Brazil
30	Chile
31	Uruguay
32	Rest of South America
33	Central America
34	Rest of the Caribbean
35	Austria
36	Belgium
37	Denmark
38	Finland
39	France
40	Germany
41	United Kingdom
42	Greece
43	Ireland
44	Italy
45	Luxembourg
46	Netherlands
47	Portugal
48	Spain
49	Sweden
50	Switzerland
51	Rest of EFTA
52	Rest of Europe
53	Albania
54	Bulgaria
55	Croatia
56	Cyprus
57	Czech Republic
58	Hungary
59	Malta
60	Poland
61	Romania
62	Slovakia
63	Slovenia
64	Estonia
65	Latvia
66	Lithuania
67	Russian Federation
68	Rest of Former Soviet Union
69	Turkey
70	Morocco
71	Tunisia
72	Rest of North Africa
73	Botswana
74	South Africa
75	Rest of South African CU
76	Malawi
77	Mozambique
78	Tanzania
79	Zambia
80	Zimbabwe
81	Madagascar
82	Uganda

Table A.3. Selected crops in version 6 used in version 7

Alfalfa
Beets for fodder
Broad beans, green
Cabbage for fodder
Carrots for fodder
Clover
Forage products, other
Green oilseeds for fodder
Grasses, other
Maize for forage and silage
Mixed grasses and legumes
Rye grass for forage and silage
Sorghum for forage and silage
Swedes for fodder
Turnips for fodder
Vegetables and roots for fodder

Figure A.1. Methods used in constructing the initial land cover data for version 7



GTAP Land Use Data - Version 7, Release 3.0, March 25, 2011:

Key improvements:

A. Updated land use data:

1) Grid cell level data used to update built-up lands;
2) A global map of potential vegetation at the grid cell level is used to calculate areas for forests, savanna_grasslands, shrublands and otherlands;
3) Forest area is weighted based on the share of accessible forest in each grid cell;
4) Corrected land cover data for Congo, DRC (formerly Zaire);
5) Updated crop production and harvested area using the most recent FAO data (downloaded March, 2011);
6) Used crop production and harvested data from version 6 for selected crops, which are not covered in the FAO data.

B. Updated land rent data:

1) Only accessible forest area is used;
2) Negative land rents are corrected.

C. Therefore, corresponding GTAP headers are revised accordingly.