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SUPPLEMENTARY MATERIAL

The global cropland footprint of the European Union’s non-food bioeconomy

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Content

1. Model classification2
2. Additional results4
 2.1. Global cropland use for non-food purposes4
 2.2. Detailed breakdown of the EU non-food cropland footprint5
 2.3. Comparison of non-food cropland footprints and net trade per region6

1. Model classification

Table S.1: List of commodities covered by the LANDFLOW model

No.	Crop commodity	No.	Livestock commodity
1	Wheat	18	Ruminants, meat and offal
2	Rice	19	Ruminants, dairy products
3	Maize	20	Ruminants, fats and meals
4	Other cereals	21	Ruminants, hides and skins
5	Roots & pulses	22	Monogastrics, meat and offal
6	Sugar crops (primary)	23	Monogastrics, eggs
7	Sugar, sweetener, molasses	24	Monogastrics, fats and meals
8	Oil crops (primary)	25	Monogastrics, hides and skins
9	Vegetable oil		
10	Oil cakes		
11	Fruit, vegetables, spices		
12	Stimulants		
13	Tobacco		
14	Rubber		
15	Other industrial crops		
16	Alcohol, non-food		
17	Fodder crops		

Table S.2. List of countries and regions covered by the LANDFLOW model

No.	ID	Regions	No.	ID	Regions
1	AUT	Austria	11	RUS	Russian Federation
2	DEU	Germany	12	AUS	Australia
3	EU28	Rest of EU-28*	13	TUR	Turkey
4	USA	United States of America	14	IDN	Indonesia
5	JPN	Japan	15	ZAF	South Africa
6	CHN	China	16	RAFR	Rest of Africa
7	CAN	Canada	17	RASI	Rest of Asia-Pacific
8	BRA	Brazil	18	REUR	Rest of Europe
9	IND	India	19	RSAM	Rest of Latin America
10	MEX	Mexico	20	RMIE	Rest of Middle East

* excluding Austria and Germany

Table S.3. Supplying and using EXIOBASE sectors of the considered non-food commodities

Nr	LANDFLOW commodity	Supplying EXIOBASE sector(s)	Using EXIOBASE sector(s)
1	Wheat	Wheat	all non-food industries
2	Rice	Paddy rice; Processed rice	all non-food industries
3	Maize	Cereal grains nec	all non-food industries
4	Other cereals	Cereal grains nec	all non-food industries
5	Roots & pulses	Vegetables, fruit, nuts	all non-food industries
6	Sugar crops (primary)	Sugar cane, sugar beet	all non-food industries
7	Sugar, sweetener, molasses	Sugar	all non-food industries
8	Oil crops (primary)	Oil seeds	all non-food industries
9	Vegetable oil	Products of vegetable oils and fats	all non-food industries
10	Oil cakes	Products of vegetable oils and fats	all non-food industries
11	Fruit, vegetables, spices	Vegetables, fruit, nuts	all non-food industries
12	Stimulants	Crops nec	all non-food industries ¹
13	Tobacco	Crops nec	Tobacco products
14	Rubber	Crops nec	Rubber and plastic products
15	Other industrial crops	Plant-based fibers	Textiles
16	Alcohol, non-food	Additives/Blending Components; Biofuels; Chemicals nec	all industries

17	Fodder crops	Crops nec	all non-food industries ¹
18	Ruminants, meat and offal	Cattle; Meat animals nec; Products of meat cattle; Meat products nec	all non-food industries ²
19	Ruminants, dairy products	Raw milk; Dairy products	all non-food industries
20	Ruminants, fats and meals	Cattle; Meat animals nec; Products of meat cattle; Meat products nec	all non-food industries ²
21	Hides & Skins, Wool, ruminants	Cattle; Meat animals nec; Animal products nec; Products of meat cattle; Meat products nec; Food products nec	Textiles; Wearing apparel, furs; Leather and leather products; Wool, silk-worm cocoons
22	Meat, monogastrics	Pigs; Poultry; Products of meat pigs; Products of meat poultry	all non-food industries ²
23	Eggs	Poultry; Animal products nec	all non-food industries
24	Monogastrics, fats and meals	Pigs; Poultry; Products of meat pigs; Products of meat poultry	all non-food industries ²
25	Monogastrics, hides and skins	Pigs; Products of meat pigs	Textiles; Wearing apparel, furs; Leather and leather products; Wool, silk-worm cocoons

Notes: 1) excluding those industries supplied with tobacco and rubber; 2) excluding those industries supplied with hides, skins and wool

2. Additional results

2.1 Global cropland use for non-food purposes

With increasing material and energetic demand for non-food bio-based products, the land area to produce these has expanded significantly over the past 15 years. Table S.4 illustrates the cropland used in each modelled region between 1995 and 2010 to supply the global non-food bioeconomy with agricultural raw materials.

Table S.4. Global cropland use for the production of agricultural raw materials supplied to the non-food bioeconomy, 1995 and 2010, in million hectares (Mha) and percentage shares.

Region	1995		2010		Changes 1995-2010	
	Mha	%	Mha	%	Mha	%
World	132.2	100%	178.3	100%	46.1	35%
Asia-Pacific	63.5	48%	81.8	46%	18.3	29%
China	12.0	9%	20.9	12%	8.9	75%
India	11.2	9%	12.4	7%	1.2	10%
Indonesia	7.0	5%	14.1	8%	7.1	102%
Australia	8.5	6%	6.0	3%	-2.5	-29%
Rest of Asia-Pacific	24.7	19%	28.3	16%	3.6	15%
Northern America	20.0	15%	30.1	17%	10.1	51%
United States of America	16.7	13%	26.0	15%	9.3	56%
Canada	3.3	2%	4.0	2%	0.8	24%
Latin America	13.3	10%	21.6	12%	8.2	62%
Mexico	1.3	1%	1.6	1%	0.3	24%
Brazil	7.1	5%	11.7	7%	4.6	66%
Rest of Latin America	5.0	4%	8.2	5%	3.3	66%
Europe	21.2	16%	23.1	13%	1.9	9%
EU-28	10.4	8%	14.6	8%	4.2	41%
Russian Federation	7.8	6%	5.5	3%	-2.3	-29%
Rest of Europe	2.9	2%	2.9	2%	0.0	-1%
Africa & Middle East	14.3	11%	21.8	12%	7.5	52%
Middle East	2.7	2%	2.8	2%	0.1	4%
Rest of Africa	11.6	9%	19.1	11%	7.4	64%

In 1995, more than 132 Mha were required for producing biomass for non-food uses. This area increased to more than 178 Mha in 2010, a growth of 37% in only 15 years, faster than population growth in this period which was 20%. In the same period, global average yields for cereals and oil crops increased by 29% and 44%, respectively (FAOSTAT, 2017). In the year 2010, non-food agricultural areas thus accounted for approximately 12% of the overall global cropland area.

With a share of 46% in 2010, Asia-Pacific was by far the largest producing region of feedstocks for the non-food bioeconomy (81.8 Mha). China, India and Indonesia were major producers of non-food products, contributing 20.9 Mha (26%), 12.4 Mha (15%) and 14.1 Mha (17%), respectively, to the Asian total in 2010. Strong increases in land requirements were observed in China and Indonesia. Growth in China was mainly related to vegetable oils and oil crops, with soybean oil being the major commodity for the production of non-food products. To a lesser extent maize for ethanol production also expanded.

The expansion in Indonesia mostly focused on vegetable oils; Indonesia is the world's largest producer of palm oil and second for coconut oil, which together accounted for 39% of its non-food cropland areas in 2010. Indonesia is also a major producer of natural rubber (27% of the non-food area in 2010), a raw material mainly used to produce car tires and latex products, but also applied in the cement and chemical industry.

Production in the USA expanded by around 10 Mha between 1995 and 2010, mostly driven by increased maize production for ethanol. Maize held a share of 60% of all non-food agricultural areas in the year 2010, making the USA the number one ethanol producer world-wide. Also Brazil, the second largest ethanol producer after the USA, increased its cropland use for non-food purposes, used mainly for the cultivation of sugar cane (50%) and oilseeds (22%), significantly from 7.1 Mha in 1995 to 11.7 Mha in 2010.

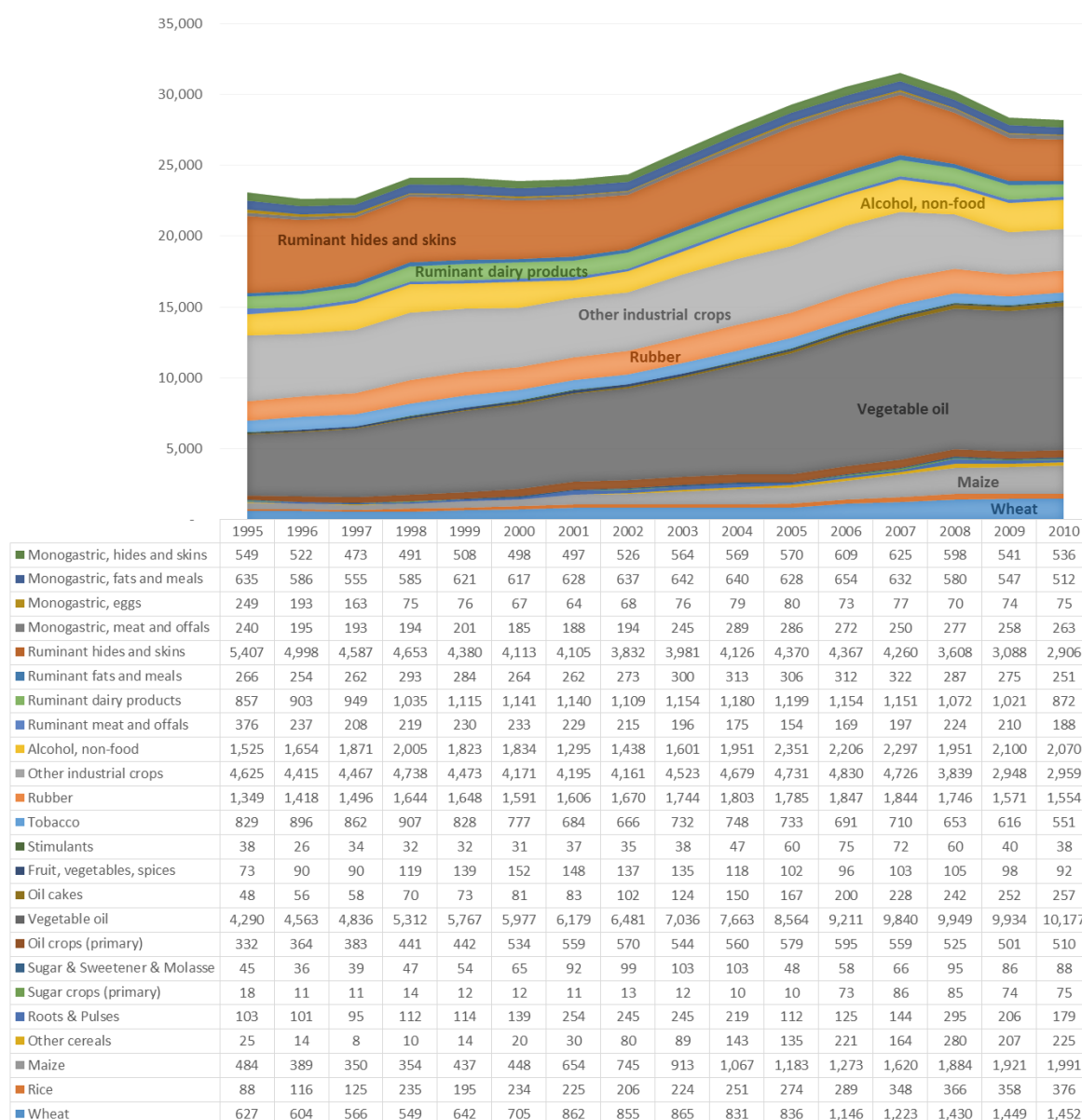
Land areas devoted to the cultivation of non-food products also grew in Africa, to more than 19 Mha in 2010, whereas land areas were decreasing in Oceania and the Russian Federation. Note that because of low yields in Africa, the physical quantity of non-food commodities produced from crop-land is lower compared to similar area extents in other parts of the world.

2.2 Detailed breakdown of the EU non-food cropland footprint

Table S.5. Global cropland footprint of the EU's consumption of non-food products in 2010, by producing region and commodity, in thousand hectares and percentage shares.

	EU-28	Rest of Europe	Africa & Middle East	Northern America	Brazil	Rest of Latin America	Australia	China	India	Indonesia	Rest of Asia-Pacific	Total	%
Crop products	6,990	1,134	1,709	2,102	787	696	89	2,496	989	2,015	3,587	22,594	80%
Wheat	993	116	35	91	1	10	34	53	0	0	119	1,452	5%
Rice	9	0	9	3	0	14	0	36	2	93	209	376	1%
Maize	166	30	5	1,196	16	29	0	494	3	22	29	1,991	7%
Other cereals	86	1	120	3	0	9	0	0	0	0	4	225	1%
Roots & pulses	33	4	84	2	0	5	1	0	0	0	50	179	1%
Sugar & sweeteners	78	5	9	0	16	24	1	0	1	1	28	164	1%
Oil crops (incl. oils & cakes)	4,639	820	490	326	177	416	14	1,191	235	1,187	1,448	10,943	39%
Fruit, vegetables, spices	50	6	11	1	1	2	0	1	1	15	5	92	0%
Coffee, tea, cocoa	0	0	34	0	1	1	0	0	0	1	1	38	0%
Tobacco	84	16	114	15	92	25	0	155	29	12	9	551	2%
Rubber	0	0	210	0	2	6	0	61	18	550	707	1,554	6%
Fibre crops	219	109	425	346	81	53	30	442	672	7	576	2,959	10%
Alcohol, non-food	632	28	162	119	401	103	9	63	26	128	400	2,070	7%
Livestock products	2,949	364	176	592	15	116	658	213	130	5	387	5,604	20%
Meat and fats	792	84	11	88	8	54	63	39	2	2	70	1,215	4%
Milk and eggs	667	108	4	109	0	1	8	22	1	0	26	947	3%
Hides, skins, wool	1,490	171	161	394	6	61	587	152	127	2	291	3,442	12%
Total	9,939	1,498	1,884	2,693	802	812	748	2,709	1,119	2,020	3,974	28,198	100%
Percentage share	35%	5%	7%	10%	3%	3%	3%	10%	4%	7%	14%	100%	

726 Figure S.4. Commodity mix of EU footprint, 1995 to 2010 in thousand hectares



729 2.3 Comparison of non-food cropland footprints and net trade per region

730 Figure S.5 and Table S.6 reveal the global consumption hotspots for cropland embodied in bio-based
731 non-food products. In 2010, In the EU-28, consumption of bio-based non-food products required 560
732 square metres per capita, while an Indian only demanded 75 square metres on average. Footprints
733 increased for almost all countries between 1995 and 2010 (Table S.6 and Figure S.6), particularly in
734 China, where it more than doubled from less than 100 to more than 200 square metres per capita
735 (from 12.1 to 27.7 Mha in absolute terms). Also North America showed a growth by more than 100
736 square metres per capita, followed by an 84 square metres increase in the EU-28. Australia and to a
737 lesser extent also the Russian Federation, South Africa, Japan, Turkey and Brazil experienced
738 reductions in their non-food cropland footprints by between 6% (for Brazil) and 44% (for South Africa).
739 This stark decline in South Africa was mainly caused by the product groups ‘ruminant hides & skins’

and ‘other industrial crops’, i.e. fibre crops and natural rubber. Besides a reduction in consumption, increased feed conversion efficiencies and crop yields may have contributed to this decrease.

Figure S.5. Consumption footprints per capita, 2010 in square meters

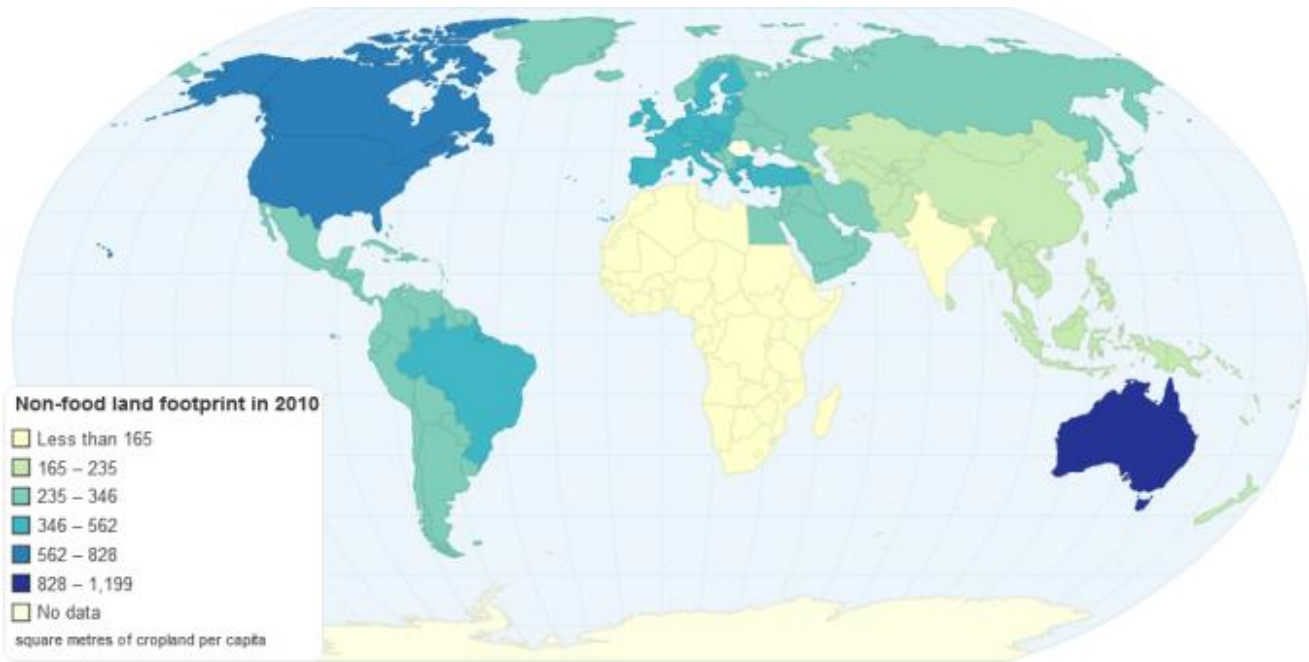
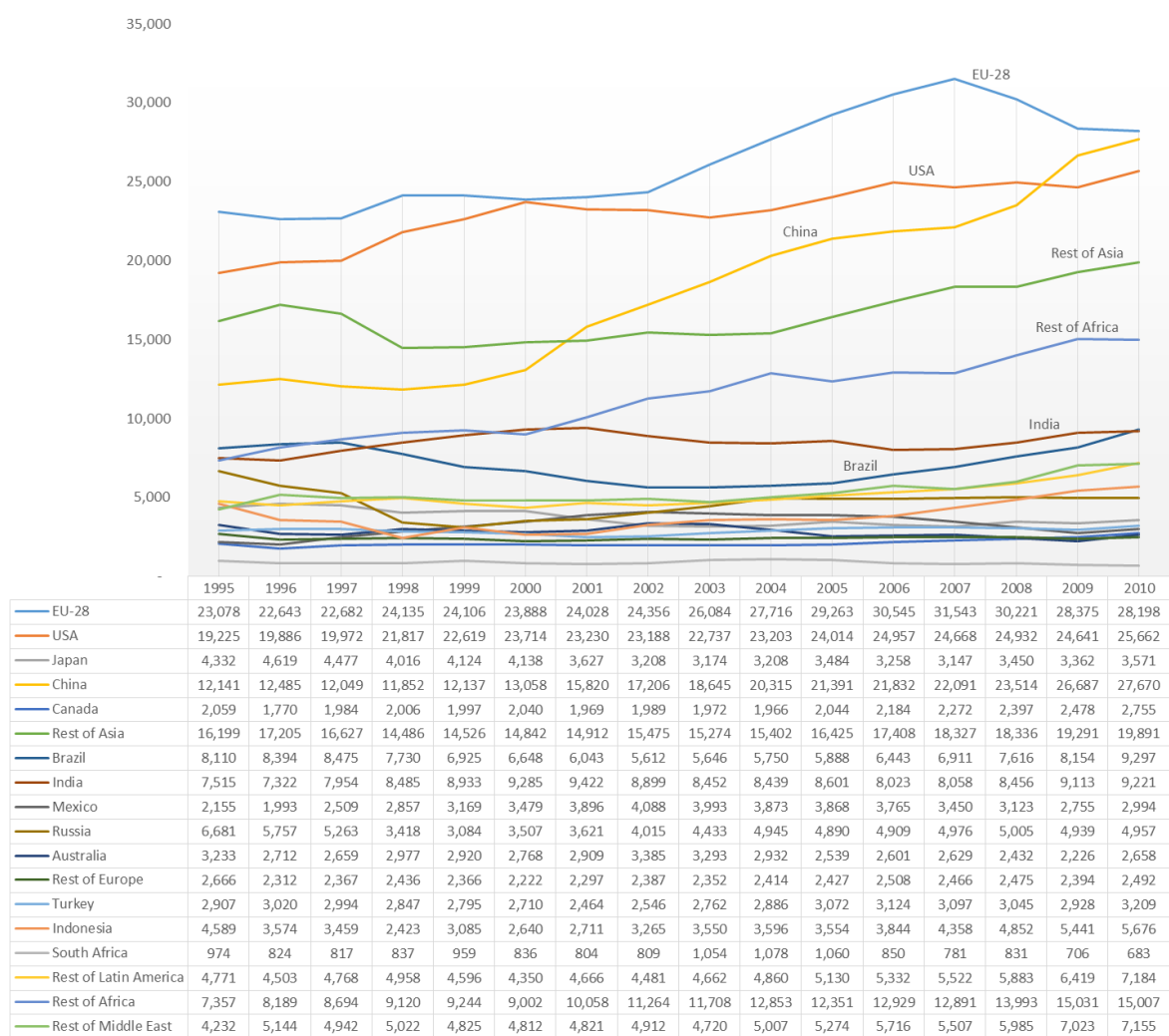


Table S.6. Consumption footprints per capita, 1995 and 2010 in square meters, change (absolute and rate)

Region	1995	2010	Change	
Australia	1784	1199	-584	-33%
USA	722	828	106	15%
Canada	703	807	104	15%
EU-28	477	562	84	18%
Brazil	498	468	-30	-6%
Turkey	497	444	-53	-11%
Russia	451	346	-104	-23%
Japan	348	280	-68	-19%
Rest of Europe	275	273	-2	-1%
Rest of Latin America	207	254	47	23%
Mexico	228	252	24	11%
Rest of Middle East	198	239	41	21%
Indonesia	233	235	2	1%
Rest of Asia	218	214	-4	-2%
China	99	206	107	109%
Rest of Africa	119	165	46	38%
South Africa	235	132	-103	-44%
India	78	75	-3	-4%

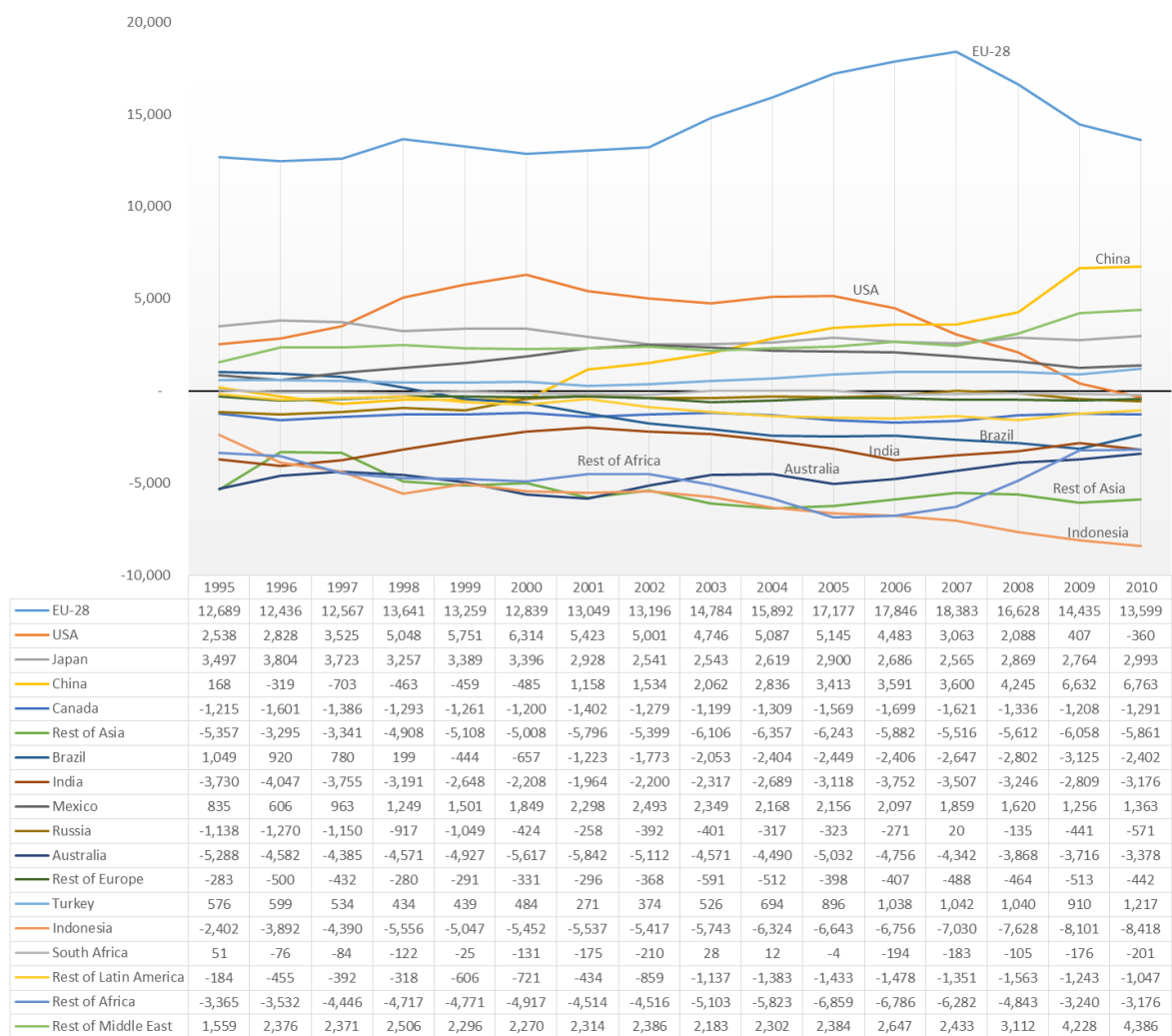
748 Figure S.6. Consumption footprints, 1995 to 2010 in thousand hectares



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751 Figure S.7. Net trade, 1995 to 2010 in thousand hectares



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