

Water Consumption by Livestock Systems from 2002–2020 and Predictions for 2030–2050 under Climate Changes in the Czech Republic

Vera Potopová ^{1,*}, Marie Musiolková ¹, Juliana Arbelaez Gaviria ², Miroslav Trnka ², Petr Havlík ³, Esther Boere ³, Tudor Trifan ¹, Nina Muntean ¹ and Md Rafique Ahasan Chawdhery ¹

¹ Department of Agroecology and Crop Production (Meteorological Section), Czech University of Life Sciences Prague, 165 00 Praha-Suchbát, Czech Republic

² Global Change Research Institute of the Czech Academy of Sciences, 603 00 Brno, Czech Republic

³ International Institute for Applied Systems Analysis (IIASA), 2361 Laxenburg, Austria

* Correspondence: potop@af.czu.cz

SUPPORTING INFORMATION: Additional supporting information

Table S1. Results of GLOBIOM models for crop/livestock products produced in cultivated areas and rainfed cultivated areas. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

Area cultivated	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
Milk (all)	1000 ha	354.43	370.34	-2.41	-0.42	0.0612	0.5823
Barley	1000 ha	399.76	225.48	-6.88	-3.79	0.9261	0.9902
Bovine meat	1000 ha	184.79	227.42	-0.88	0.77	0.0000	0.3250
Corn	1000 ha	45.82	17.30	-1.07	-0.80	0.6590	0.7779
Corn Silage	1000 ha	116.43	107.77	-1.71	-0.39	0.3015	0.9073
Oats	1000 ha	60.56	77.15	0.44	0.52	0.9562	0.9652
Rye	1000 ha	23.95	42.76	0.54		0.9857	
Sheep and goat meat	1000 ha	5.84	5.55	-0.03	-0.01	0.0973	0.8900
Wheat	1000 ha	768.33	520.62	-7.26	-3.96	0.7932	0.9759
Area cultivated – rainfed							
Barley	1000 ha	399.76	225.48	-6.88	-3.79	0.9261	0.9902
Corn	1000 ha	45.82	17.30	-1.07	-0.80	0.6590	0.7779
Corn Silage	1000 ha	116.43	107.77	-1.71	-0.39	0.3015	0.9073
Oats	1000 ha	60.56	77.15	0.44	0.52	0.9562	0.9652
Rye	1000 ha	23.95	42.76	0.54		0.9857	
Wheat	1000 ha	768.33	520.62	-7.26	-3.96	0.7932	0.9759

Table S2. Results of GLOBIOM models for land cover types. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R^2).

Land Cover	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R^2 (min)	R^2 (max)
Cropland	1000 ha	2469.20	1651.84	-29.94	-15.89	0.9129	0.9847
Grassland	1000 ha	545.06	603.32	-3.33	0.19	0.0001	0.5018
Other Natural Land	1000 ha	1483.86	2135.05	16.16	27.34	0.9500	0.9690

Table S3. Results of GLOBIOM models for crop yields and rainfed crop yields. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R^2).

Crop yield	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R^2 (min)	R^2 (max)
Milk (all)	fm t/ha	6.22	4.42	-0.05	-0.03	0.3843	0.7855
Barley	fm t/ha	5.69	5.97	0.03	0.05	0.6088	0.8616
Bovine meat	fm t/ha	0.54	0.44	0.00	0.00	0.1634	0.8587
Corn	fm t/ha	6.88	11.33	0.07	0.16	0.6590	0.8606
Corn Silage	fm t/ha	32.97	31.62	-0.06	-0.02	0.9447	0.9858
Oats	fm t/ha	3.60	4.05	0.02		0.9657	
Rye	fm t/ha	4.55	5.36	0.02		0.9503	
Sheep and goat meat	fm t/ha	0.47	0.50	0.00	0.00	0.0001	0.9310
Wheat	fm t/ha	6.43	6.39	0.02	0.03	0.3372	0.7642
Crop yield – rainfed							
Barley	fm t/ha	5.69	5.97	0.03	0.05	0.6088	0.8616
Corn	fm t/ha	6.88	11.33	0.07	0.16	0.6590	0.8606
Corn Silage	fm t/ha	32.97	31.62	-0.06	-0.02	0.9447	0.9858
Oats	fm t/ha	3.60	4.05	0.02		0.9657	0.9669
Rye	fm t/ha	4.55	5.36	0.02		0.9503	
Wheat	fm t/ha	6.43	6.39	0.02	0.03	0.3372	0.7642

Table S4. Results of GLOBIOM models for crops used as feed for livestock. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R^2).

Feed use	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R^2 (min)	R^2 (max)
Barley	1000 t	865.11	516.73	-14.51	-14.14	0.9767	0.9817
Corn	1000 t	486.59	310.35	-1.78	-1.44	0.0746	0.1047
Corn Silage	1000 t	3841.07	3423.85	-61.39	-16.28	0.4113	0.9263
Oats	1000 t	9.49	0.00	-2.29		0.7354	0.7358
Rape (RapC)	1000 t	250.09	101.47	-4.02	-3.71	0.4974	0.5230
Rapeseed Oil	1000 t	12.87	8.68	-0.17	-0.17	0.9806	0.9823
Rye	1000 t	3.89	0.00	-0.94	-0.94	0.7354	0.7358
Wheat	1000 t	1515.12	894.98	-25.25	-24.60	0.9769	0.9821

Table S5. Results of GLOBIOM models for ruminant meat and ruminant milk for different production systems. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

Ruminant meat	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
LGT Livestock only systems Temperate	1000 t	4.21	23.93	0.38	0.59	0.8517	0.9548
MRT Mixed rainfed Temperate	1000 t	39.76	21.59	-0.98	-0.76	0.8586	0.9648
Other areas	1000 t	20.90	22.37	0.05	0.05	0.9933	0.9965
Urban areas	1000 t	6.90	7.39	0.02	0.02	0.9943	0.9971
Ruminant milk							
LGT Livestock only systems Temperate	1000 t	0.04	0.02	0.00	0.00	0.9124	0.9450
MRT Mixed rainfed Temperate	1000 t	1109.61	583.14	-26.24	-20.48	0.8655	0.9719
Other areas	1000 t	637.59	653.93	0.47	0.47	0.9819	0.9887
Urban areas	1000 t	215.86	221.40	0.16	0.16	0.9814	0.9885

Table S6. Results of GLOBIOM models for ruminant meat and ruminant milk for different production systems. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

Biofuel	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
Rape	1000 t	102.0	255.4	3.52		0.7090	
Oil							
Wheat	1000 t	13.9	595.1	13.14		0.7681	

Table S7. Results of GLOBIOM models for emissions from the crop/livestock production. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

Emissions	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
Milk (all)	Mt CO ₂ eq/yr	1.49	1.18	-0.02	-0.01	0.8814	0.9809
Barley	Mt CO ₂ eq/yr	0.43	0.20	0.00	0.00	0.1287	0.6896
Bovine meat	Mt CO ₂ eq/yr	0.83	1.00	0.00	0.00	0.0078	0.1247
Corn*	Mt CO ₂ eq/yr	0.04	0.02	0.00	0.00	0.1423	0.5598
Crop	Mt CO ₂ eq/yr	2.63	1.66	-0.02	0.00	0.0091	0.6098
Corn Silage	Mt CO ₂ eq/yr	0.10	0.09	0.00	0.00	0.4420	0.8493
Livestock	Mt CO ₂ eq/yr	2.76	2.45	-0.02	-0.02	0.7692	0.9012
Oats	Mt CO ₂ eq/yr	0.03	0.04	0.00	0.00	0.9326	0.9644
Pig meat	Mt CO ₂ eq/yr	0.36	0.22	-0.01	-0.01	0.9862	0.9862
Poultry eggs	Mt CO ₂ eq/yr	0.02	0.02	0.00	0.00	0.8893	0.9213
Poultry meat	Mt CO ₂ eq/yr	0.04	0.02	0.00	0.00	0.9560	0.9667
Rye	Mt CO ₂ eq/yr	0.02	0.03	0.00	0.00	0.9560	0.9667
Sheep and goat meat	Mt CO ₂ eq/yr	0.02	0.02	0.00	0.00	0.1080	0.9170
Wheat	Mt CO ₂ eq/yr	0.99	0.53	-0.01	0.00	0.2075	0.3617

Table S8. Results of GLOBIOM models for net trade of the crop/livestock products. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

Net Trade	Unit	Values for individual years		Regression characteristics			
		2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
Milk (all)	1000 t	-275.72	-991.49	-28.10	-21.36	0.9303	0.9882
Barley	1000 t	704.93	82.78	-11.35	1.17	0.0138	0.6179
Bovine meat	1000 t	-18.16	-37.73	-1.27	-0.95	0.8384	0.9622
Corn	1000 t	-312.05	-458.21	-6.84	-5.23	0.6335	0.8579
Oats	1000 t	146.97	251.58	4.82	5.12	0.9529	0.9708
Pig meat	1000 t	-198.21	-335.39	-7.16	-6.96	0.9290	0.9501
Poultry eggs	1000 t	32.28	21.63	0.38	0.41	0.3464	0.4568
Poultry meat	1000 t	-95.60	-158.51	-2.71	-2.66	0.9382	0.9504
Rapeseed oil	1000 t	95.79	-360.76	-8.83	-8.59	0.7509	0.7748
Rye	1000 t	-34.37	93.36	4.70	4.73	0.9825	0.9851
Sheep and goat meat	1000 t	-0.44	-0.25	-0.01	0.00	0.0005	0.5732
Wheat	1000 t	2132.96	476.39	-2.34	14.58	0.0001	0.1244

Table S9. Results of GLOBIOM models for calories and calories target of the crop/livestock products. Average values for the years 2020 and 2050 are presented for mutual comparison, and results of linear models of development of values from 2000 to 2050 are chosen as the minimum and maximum values from all GLOBIOM models for regression coefficient (a) and coefficient of determination (R²).

		Values for individual years		Regression characteristics			
Calories	Unit	2020	2050	a (min)	a (max)	R ² (min)	R ² (max)
Milk (all)	kcal/cap/d	341.23	338.31	-0.37	-0.29	0.6146	0.8239
Barley	kcal/cap/d	306.89	297.82	1.74	1.86	0.5990	0.6871
Bovine meat	kcal/cap/d	25.73	27.66	0.05	0.06	0.3671	0.5202
Oats	kcal/cap/d	1.84	1.71	0.00	0.00	0.0167	0.0532
Pig meat	kcal/cap/d	221.33	204.83	-0.04	0.03	0.0001	0.0071
Poultry eggs	kcal/cap/d	33.32	27.53	-0.65	-0.64	0.8200	0.8408
Poultry meat	kcal/cap/d	89.32	87.33	-0.02	0.00	0.0002	0.0123
Rapeseed oil	kcal/cap/d	278.57	353.71	2.45	2.68	0.7628	0.7972
Rye	kcal/cap/d	69.45	63.42	-0.45	-0.44	0.6872337	0.7256997
Sheep and goat meat	kcal/cap/d	1.58	1.40	-0.01	0.00	0.0806	0.7234
Wheat	kcal/cap/d	511.5	508.6	-3.97	-3.85	0.6953	0.7107
Calories Target							
Milk (all)	kcal/cap/d	323.65	323.65	-0.47		0.4286	
Barley	kcal/cap/d	295.18	295.19	1.73		0.7087	
Bovine meat	kcal/cap/d	23.78	26.42	0.05		0.1824	
Oats	kcal/cap/d	1.80	1.69	0.00		0.0020	
Pig meat	kcal/cap/d	181.09	181.09	-0.44		0.6689	
Poultry eggs	kcal/cap/d	28.56	25.54	-0.67		0.7746	
Poultry meat	kcal/cap/d	83.91	83.91	-0.06		0.1097	
Rapeseed oil	kcal/cap/d	325.53	419.37	3.69		0.8928	
Rye	kcal/cap/d	66.60	62.43	-0.45		0.6628	
Sheep and goat meat	kcal/cap/d	1.33	1.18	-0.01		0.9139	
Wheat	kcal/cap/d	501.99	502.01	-4.10		0.7086	