

Supplementary Information

The Water Footprint of Agriculture in Duero River Basin. Sustainability 2015, 7, 6759-6780

Ángel de Miguel ^{1,*}, Malaak Kallache ¹ and Eloy García-Calvo ^{1,2}

¹ IMDEA Water Institute, c/Punto Net 4, P.O. Box 28805, Alcalá de Henares, Madrid 28805, Spain; E-Mails: mkallache@gmx.de (M.K.); eloy.garcia@imdea.org (E.G.-C.)

² Department of Analytical Chemistry, Physical Chemistry and Chemical Engineering, University of Alcalá, P.O. Box 28805, Alcalá de Henares, Madrid 28805, Spain

* Author to whom correspondence should be addressed; E-Mail: angel.demiguel@imdea.org; Tel.: +34-91-830-59-62; Fax: +34-91-830-59-61.

Table S1. Harvested area, production and WF_{green} , WF_{blue} and WF_{grey} of crops in Duero river basin, average values for the period 2003–2007.

	Crop	System	Surface (ha)	Production (1000 tons)	WF_{green} (1000 m ³)	WF_{blue} (1000 m ³)	WF_{grey} (1000 m ³)	WF_{Total} (1000 m ³)	WF_{Total} (1000 m ³ /ha)
Cereals	Wheat	Rainfed	497,483	1468	1,253,346	0	150,941	1,404,287	2823
		Irrigated	46,457	222	92,788	138,284	10,778	241,850	5206
	Barley	Rainfed	1,064,767	2889	2,455,155	0	491,269	2,946,424	2767
		Irrigated	104,804	471	199,357	290,800	76,296	566,452	5405
	Oat	Rainfed	111,207	227	241,307	0	33,499	274,806	2471
		Irrigated	10,751	36	20,630	26,153	7887	54,669	5085
	Rye	Rainfed	67,688	113	141,482	0	20,589	162,071	2394
		Irrigated	1898	6	3198	1964	1032	6195	3264
	Maize	Rainfed	2280	23	4442	0	7701	12,143	5326
		Irrigated	126,195	1289	222,571	672,054	719,770	1,614,395	12,793
Legumes	Vetch	Rainfed	101,244	73	122,197	0	2682	124,879	1233
		Irrigated	2240	4	4803	5957	72	10,832	4835
	Lentils	Rainfed	16,597	12	15,881	0	185	16,066	968
		Irrigated	0	0	0	0	0	0	0
	Other legumes	Rainfed	56,887	72	142,555	0	278	142,833	2511
		Irrigated	13,722	26	14,475	5500	669	20,645	1504
Tuber	Potatoes	Rainfed	1295	26	2236	0	5715	7951	6141
		Irrigated	19,753	779	26,850	94,557	200,513	321,920	16,297
Industrial crops	Sugar beet	Rainfed	593	30	1268	0	208	1476	2490
		Irrigated	45,850	3681	89,340	286,906	200,028	576,274	12,569
	Sunflower	Rainfed	142,641	128	253,946	0	556	254,502	1784
		Irrigated	17,575	33	23,274	69,420	280	92,974	5290

Table S1. *Cont.*

	Crop	System	Surface (ha)	Production (1000 tons)	WF _{green} (1000 m³)	WF _{blue} (1000 m³)	WF _{grey} (1000 m³)	WF _{Total} (1000 m³)	WF _{Total} (1000 m³/ha)
Cereals	Wheat	Rainfed	497,483	1468	1,253,346	0	150,941	1,404,287	2823
		Irrigated	46,457	222	92,788	138,284	10,778	241,850	5206
	Barley	Rainfed	1,064,767	2889	2,455,155	0	491,269	2,946,424	2767
		Irrigated	104,804	471	199,357	290,800	76,296	566,452	5405
	Oat	Rainfed	111,207	227	241,307	0	33,499	274,806	2471
		Irrigated	10,751	36	20,630	26,153	7887	54,669	5085
	Rye	Rainfed	67,688	113	141,482	0	20,589	162,071	2394
		Irrigated	1898	6	3198	1964	1032	6195	3264
	Maize	Rainfed	2280	23	4442	0	7701	12,143	5326
		Irrigated	126,195	1289	222,571	672,054	719,770	1,614,395	12,793
Legumes	Vetch	Rainfed	101,244	73	122,197	0	2682	124,879	1233
		Irrigated	2240	4	4803	5957	72	10,832	4835
	Lentils	Rainfed	16,597	12	15,881	0	185	16,066	968
		Irrigated	0	0	0	0	0	0	0
	Other legumes	Rainfed	56,887	72	142,555	0	278	142,833	2511
		Irrigated	13,722	26	14,475	5500	669	20,645	1504
Tuber	Potatoes	Rainfed	1295	26	2236	0	5715	7951	6141
		Irrigated	19,753	779	26,850	94,557	200,513	321,920	16,297
Industrial crops	Sugar beet	Rainfed	593	30	1268	0	208	1476	2490
		Irrigated	45,850	3681	89,340	286,906	200,028	576,274	12,569
	Sunflower	Rainfed	142,641	128	253,946	0	556	254,502	1784
		Irrigated	17,575	33	23,274	69,420	280	92,974	5290
Forages	Alfalfa	Rainfed	27,639	706	83,414	0	702	84,116	3043
		Irrigated	32,125	1730	82,754	222,636	1608	306,998	9556
	Prairie	Rainfed	1419	24	2916	0	93	3008	2120
		Irrigated	0	0	0	0	0	0	0
	Other forages	Rainfed	28,560	315	44,133	0	2299	46,431	1626
		Irrigated	0	0	0	0	0	0	0
Vegetables	Garlic	Rainfed	0	0	0	0	0	0	0
		Irrigated	852	11	1476	1184	7642	10,303	12,086
	Onion	Rainfed	0	0	0	0	0	0	0
		Irrigated	768	31	1093	2337	9891	13,322	17,351
	Carrots	Rainfed	0	0	0	0	0	0	0
		Irrigated	2387	128	2745	9772	3575	16,093	6741
	Other vegetables	Rainfed	0	0	0	0	0	0	0
		Irrigated	4825	132	5973	23,525	39,638	69,136	14,329
Vineyards	Wine grape	Rainfed	58,558	236	59,333	0	7878	67,211	1148
		Irrigated	2299	15	1123	593	1205	2921	1270
Total crops		Rainfed	2,178,857	6342	4,823,611	0	724,594	5,548,205	2546
		Irrigated	432,502	8593	792,452	1,851,644	1,280,883	3,924,979	9075
		Total	2,611,359	14,935	5,616,063	1,851,644	2,005,478	9,473,184	3628

Table S2. Harvested area, production and WF_{green} , WF_{blue} and WF_{grey} of the 13 *WMU* in Spanish Duero river basin, average for the period 2003–2007.

Water Management Unit	Surface (ha)	Production (1000 tons)	WF_{green} (1000 m ³)	WF_{blue} (1000 m ³)	WF_{grey} (1000 m ³)	WF_{total} (1000 m ³)
1. Támgea-Manzanas	7193	51	0	5312	17,332	22,644
2. Tera	27,839	245	47,286	33,373	136,902	217,560
3. Órbigo	92,476	1208	325,377	225,098	719,436	1,269,911
4. Esla-Valderaduey	266,929	1598	279,110	207,796	1,061,710	1,548,616
5. Carrión	303,998	1770	186,411	130,293	965,671	1,282,375
6. Pisuerga	346,125	1703	138,029	194,399	1,099,388	1,431,817
7. Arlanza	217,361	863	34,587	115,343	659,251	809,181
8. Alto Duero	277,723	969	77,086	134,672	866,339	1,078,097
9. Rianza-Duratón	151,738	751	65,431	86,239	481,956	633,626
10. Cega-Eresma-Adaja	259,402	1392	137,355	201,142	929,740	1,268,238
11. Bajo Duero	454,296	2984	417,456	470,329	1,792,813	2,680,598
12. Tormes	150,805	1027	130,814	166,726	598,903	896,442
13. Águeda	55,473	375	12,703	34,754	143,743	191,199
Total	2,611,359	14,935	1,851,644	2,005,478	9,473,184	13,330,306

Table S3. WF_{blue} and water abstraction by source of water for the 13 *WMU* in Spanish Duero river basin, average for the period 2003–2007.

Water Management Unit	Superficial Water		Ground Water		Total Blue Water Abstraction
	WF_{blue}	Blue Water Abstraction	WF_{blue}	Blue Water Abstraction	
	(1000 m ³)	(1000 m ³)	(1000 m ³)	(1000 m ³)	
1. Támgea-Manzanas	0	0	0	0	0
2. Tera	43,987	111,821	3292	4389	116,210
3. Órbigo	317,128	652,678	8204	10,939	663,617
4. Esla-Valderaduey	203,689	390,063	75,383	100,510	490,573
5. Carrión	141,737	357,196	44,649	59,532	416,728
6. Pisuerga	91,384	203,664	46,627	62,169	265,833
7. Arlanza	19,612	29,085	14,970	19,960	49,045
8. Alto Duero	68,495	143,436	8581	11,441	154,877
9. Rianza-Duratón	38,943	82,274	26,479	35,305	117,580
10. Cega-Eresma-Adaja	28,253	22,402	109,083	145,444	167,846
11. Bajo Duero	114,067	186,722	303,332	404,443	591,165
12. Tormes	91,169	158,103	39,627	52,836	210,939
13. Águeda	4618	11,639	8083	10,777	22,416
Total	1,163,084	2,349,083	688,309	917,746	3,266,829

Table S4. Application, crop extraction, leaching and WF_{grey} of nitrogen used as fertiliser per crop in the Duero river basin, average values for the 2003–2007 period.

	Crop	System	N Application (tons)	N Extract by Crops (tons)	N Leached (tons)	WF_{grey} (1000 m ³)	WF_{grey} (m ³ /ha)	WF_{grey} 10% (1000 m ³)	Leaching Rate
Cereals	Wheat	Rainfed	36,716	34,242	1629	150,941	30,341	340,281	0.04
		Irrigated	5182	5161	116	10,778	23,200	48,025	0.02
	Barley	Rainfed	74,577	54,892	5301	491,269	46,139	691,165	0.07
		Irrigated	11,233	8930	823	76,296	72,798	104,108	0.07
	Oat	Rainfed	5348	4459	361	33,499	30,123	49,568	0.07
		Irrigated	1011	720	85	7887	73,356	9365	0.08
	Rye	Rainfed	2710	2140	222	20,589	30,417	25,111	0.08
		Irrigated	161	98	11	1032	54,365	1488	0.07
	Maize	Rainfed	595	358	83	7701	337,793	5518	0.14
		Irrigated	53,423	27,714	7766	719,770	570,363	495,114	0.15
Legumes	Vetch	Rainfed	999	3946	29	2682	2649	9256	0.03
		Irrigated	79	154	1	72	3204	732	0.01
	Lentils	Rainfed	149	511	2	185	1117	1384	0.01
		Irrigated	0	0	0	0	0	0	
	Other legumes	Rainfed	171	3010	3	278	489	1582	0.02
		Irrigated	736	1081	7	669	4877	6822	0.01
Tuber	Potatoes	Rainfed	293	117	62	5715	441,374	2713	0.21
		Irrigated	7912	4210	2164	200,513	1,015,102	73,328	0.27
Industrial crops	Sugar beet	Rainfed	103	116	2	208	35,060	953	0.02
		Irrigated	18,688	14,060	2158	200,028	436,265	173,202	0.12
	Sunflower	Rainfed	974	5236	6	556	390	9023	0.01
		Irrigated	552	1313	3	280	1593	5117	0.01
Forages	Alfalfa	Rainfed	385	2846	8	702	2539	3571	0.02
		Irrigated	1107	9234	17	1608	5005	10,261	0.02
	Prairie	Rainfed	17	90	1	93	65,0	159	0.06
		Irrigated	0	0	0	0	0	0	0
	Other forages	Rainfed	475	1865	25	2299	8049	4401	0.05
		Irrigated	0	0	0	0	0	0	0
Vegetables	Garlic	Rainfed	0	0	0	0	0	0	0
		Irrigated	256	99	82	7642	896,534	2377	0.32
	Onion	Rainfed	0	0	0	0	0	0	0
		Irrigated	247	94	107	9891	1,288,267	2285	0.43
	Carrots	Rainfed	0	0	0	0	0	0	0
		Irrigated	606	736	39	3575	149,774	5618	0.06
	Other vegetables	Rainfed	0	0	0	0	0	0	0
		Irrigated	1458	807	428	39,638	821,540	13,514	0.29
Vineyards	Wine grape	Rainfed	897	1201	85	7878	13,453	8313	0.09
		Irrigated	182	75	13	1205	52,407	1687	0.07
Total crops		Rainfed	124,409	115,030	7818	724,594	33,256	1,152,999	0.06
		Irrigated	102,833	74,485	13,821	1,280,883	296,157	953,042	0.13
		Total	227,242	189,515	21,639	2,005,478	76,798	2,106,041	0.10

Table S5. Yield, WF_{green} , WF_{blue} , WF_{grey} per ton of product and CWP of crops in Duero river basin, average values for the period 2003–2007.

	Crop	System	Yield (kg/ha)	WF_{green} (m ³ /ton)	WF_{blue} (m ³ /ton)	WF_{grey} (m ³ /ton)	WF_{total} (m ³ /ton)	CWP (m ³ /ton)	CWP (ton/m ³)
Cereals	Wheat	Rainfed	2911	866	0	103	968	866	1.16
		Irrigated	4775	418	637	49	1104	1055	0.95
		W, Average	3070	806	85	96	987	891	1.12
	Barley	Rainfed	2708	852	0	170	1022	852	1.17
		Irrigated	4487	424	627	162	1213	1051	0.95
		W, Average	2867	792	88	169	1048	880	1.14
	Oat	Rainfed	2027	1070	0	148	1218	1070	0.93
		Irrigated	3411	563	686	219	1468	1249	0.80
		W, Average	2149	999	96	157	1253	1095	0.91
	Rye	Rainfed	1678	1245	0	182	1428	1245	0.80
		Irrigated	3008	560	350	172	1082	910	1.10
		W, Average	1715	1213	17	182	1411	1229	0.81
	Maize	Rainfed	9925	196	0	341	537	196	5.09
		Irrigated	10280	172	525	558	1255	696	1.44
		W, Average	10274	172	516	555	1242	688	1.45
Legumes	Vetch	Rainfed	704	1714	0	37	1750	1714	0.58
		Irrigated	1578	1358	1715	19	3092	3073	0.33
		W, Average	1217	2048	84	36	2168	2132	0.47
	Lentils	Rainfed	741	1291	0	15	1307	1291	0.77
		Irrigated	0	0	0	0	0	0	0
		W, Average	741	1291	0	15	1307	1291	0.77
	Other legumes	Rainfed	1203	2084	0	4	2087	2084	0.48
		Irrigated	1853	569	219	26	814	788	1.27
		W, Average	842	1413	58	10	1480	1470	0.68
Tuber	Potatoes	Rainfed	16,420	105	0	217	322	105	9.51
		Irrigated	39,225	35	123	257	415	158	6.34
		W, Average	37,822	37	120	256	412	156	6.39
Industrial crops	Sugar beet	Rainfed	50,118	43	0	7	50	43	23.43
		Irrigated	80,355	24	79	54	158	103	9.69
		W, Average	79,969	24	78	54	157	103	9.73
	Sunflower	Rainfed	891	1997	0	4	2002	1997	0.50
		Irrigated	1768	749	2273	8	3030	3022	0.33
		W, Average	988	1752	446	5	2204	2199	0.45
Forages	Alfalfa	Rainfed	18,439	164	0	1	165	164	6.11
		Irrigated	50,168	51	142	1	194	193	5.18
		W, Average	35,494	78	108	1	186	186	5.38
	Prairie	Rainfed	17,424	118	0	4	122	118	8.48
		Irrigated	0	0	0	0	0	0	0
		W, Average	17,424	118	0	4	122	118	8.48
	Other forages	Rainfed	12,328	125	0	7	133	125	7.98
		Irrigated	0	0	0	0	0	0	0
		W, Average	12,328	125	0	7	133	125	7.98

Table S5. *Cont.*

Crop	System	Yield (kg/ha)	WF _{green} (m ³ /ton)	WF _{blue} (m ³ /ton)	WF _{grey} (m ³ /ton)	WF _{total} (m ³ /ton)	CWP (m ³ /ton)	CWP (ton/m ³)
Vegetables	Rainfed	0	0	0	0	0	0	0
	Garlic Irrigated	10,955	158	129	684	971	287	3.48
	W, Average	10,955	158	129	684	971	287	3.48
	Rainfed	0	0	0	0	0	0	0
	Onion Irrigated	40,514	35	84	323	442	120	8.36
	W, Average	40,514	35	84	323	442	120	8.36
	Rainfed	0	0	0	0	0	0	0
	Carrots Irrigated	62,062	19	69	28	116	87	11.43
	W, Average	62,062	19	69	28	116	87	11.43
	Rainfed	0	0	0	0	0	0	0.00
	Other vegetables Irrigated	24,666	50	200	300	550	250	4.00
	W, Average	24,666	50	200	300	550	250	4.00
Vineyards	Rainfed	4311	235	0	33	268	235	4.25
	Wine grape Irrigated	11,146	44	23	81	148	67	14.93
	W, Average	2830	224	1	36	261	225	4.44
Total crops	Rainfed	2825	804	0	114	918	806	1.24
	Irrigated	19,663	94	225	149	468	316	3.17
	W, Average	5613	384	128	134	646	512	1.95

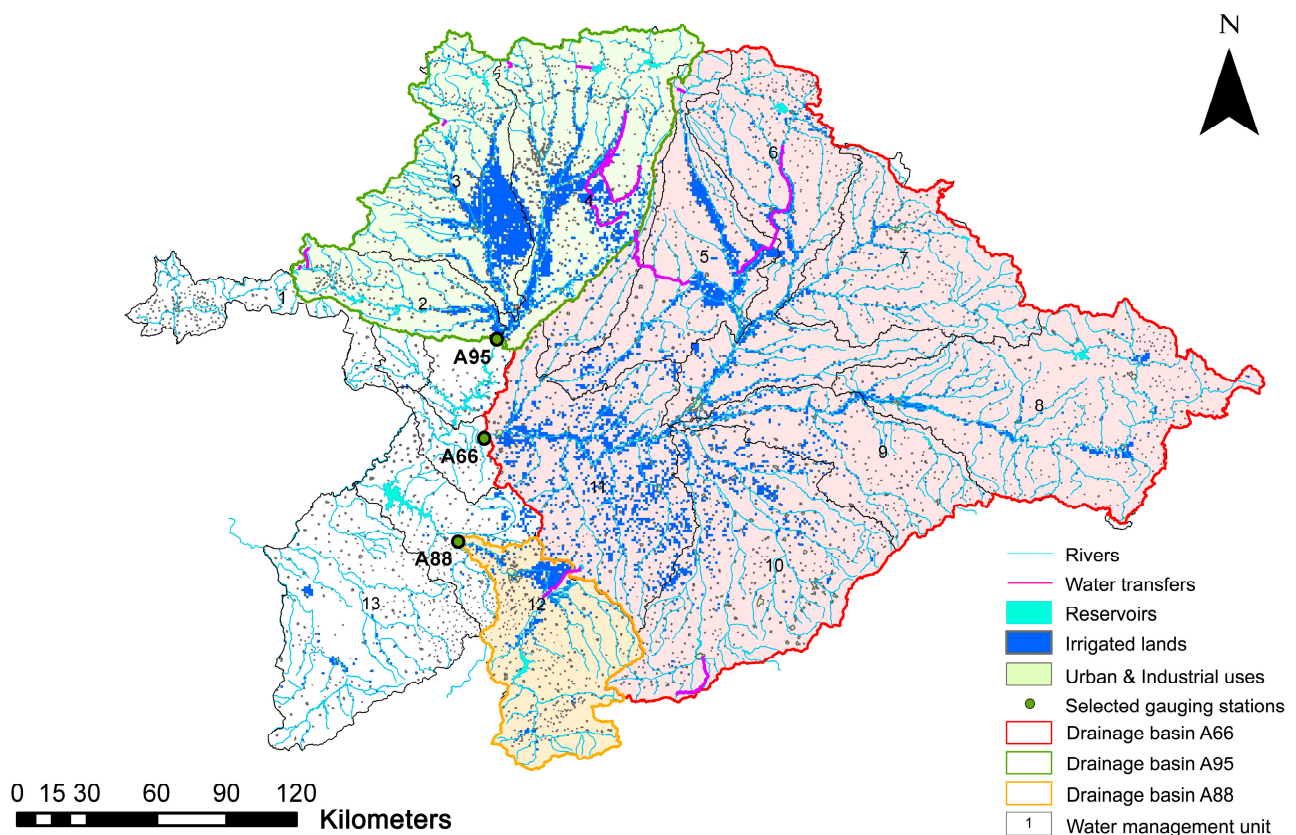


Figure S1. Localization of gauging stations and drainage basin used to estimate the blue water scarcity index.

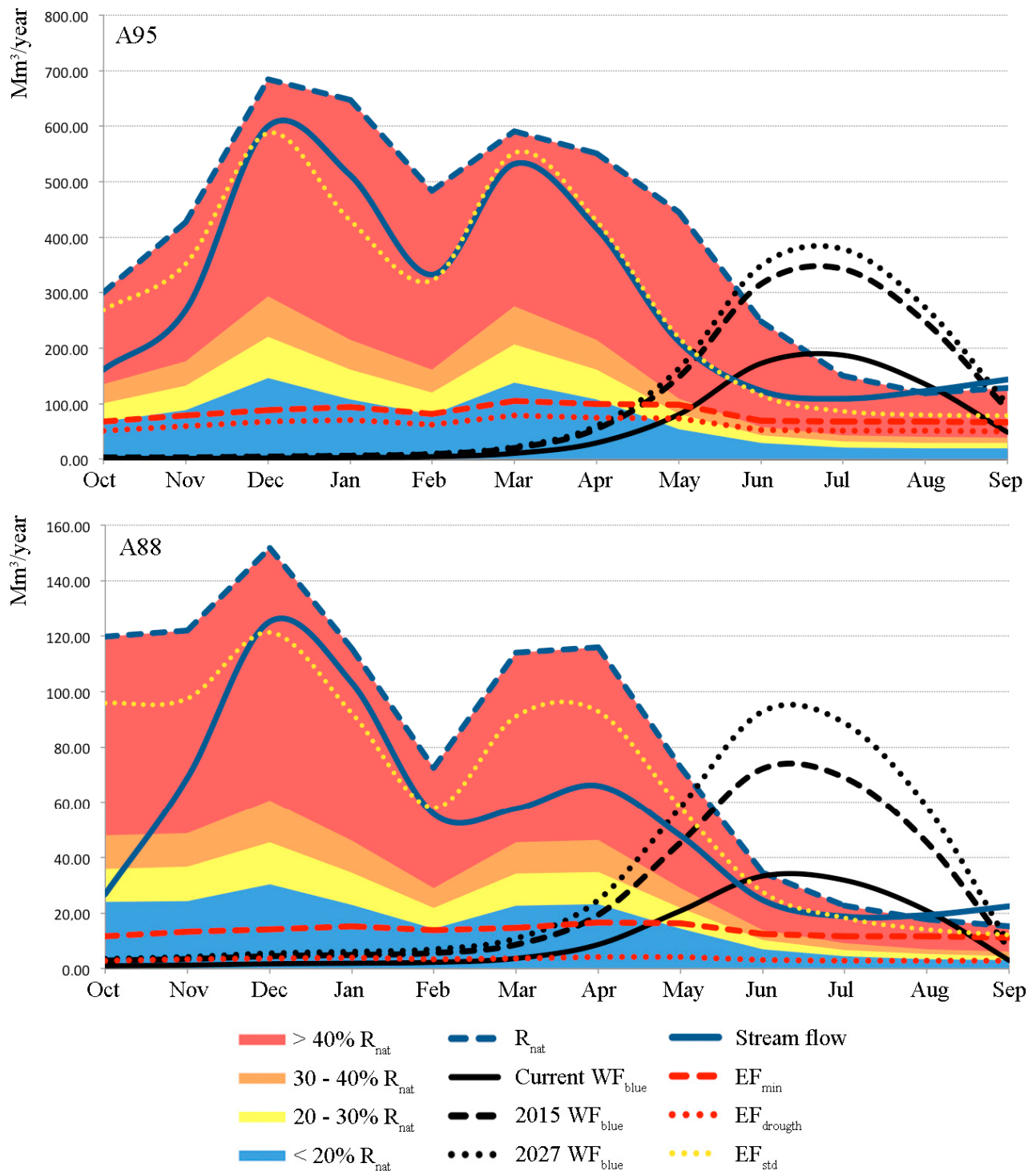


Figure S2. Blue water scarcity index of the drainage basin A95 and A88 for the simulated period (average 2003–2007) and for the planning horizons 2015 and 2027.