

Phosphorus demand for food security: a case study of a food-deficient country

1. Supplementary method, data and results

1.2. Supplementary method

Tables S1 illustrate data, and calculation of embedded phosphorus flows through agricultural commodities trade in 1991.

Table S1. Embedded phosphorus calculation

Food group	Food items	Import (Mt)	Export (Mt)	Estimation of Embedded phosphorus (kg)
Cereals	Wheat flour	2,624		9,082
	Rice	28,120		33,744.50
Livestock	Red meat	1,640		3,527.48
	Poultry meat	650		1,501.50
Dairy products	Milk	1,180		4,460.36
Sugar	Sugar	3,974		874.28
Agricultural export items	Vanilla		1,090	655.15
	Cloves		2,104	1,893.60

Sources: FAOSTAT, Central Bank of Comoros, trade statistics

Tables S2; S3; S4; S5; S6; S7; S8; S9; S10 and S11 illustrate the materials and data used for the imported and exported agricultural commodities and the calculation of the SSR.

Table S2. Rice imports

Year	Production (Mt)	Import (Mt)	Export (Mt)	Net import (Mt)	Population	Consumption per capita (Mt/year)	Self-sufficiency ratio (%)
1991	3,050	28,120	0	-25,070	423,872	0.073	9.78
1992	3,000	32,493	0	-29,493	436,448	0.081	8.45
1993	3,000	30,271	0	-27,271	449,274	0.074	9.01
1994	3,000	28,518	0	-25,518	462,277	0.068	9.51
1995	3,000	41,650	0	-38,650	475,394	0.093	6.71
1996	3,000	30,538	0	-27,538	488,627	0.068	8.94
1997	2,965	34,323	0	-31,358	501,953	0.074	7.95
1998	2,960	34,718	0	-31,758	515,385	0.073	7.85
1999	2,960	35,353	0	-32,393	528,848	0.072	7.72
2000	2,955	30,000	0	-27,045	542,357	0.060	8.96
2001	1,170	26,150	0	-24,980	555,888	0.049	4.28
2002	1,165	29,293	0	-28,128	569,479	0.053	3.82
2003	1,161	28,753	0	-27,592	583,211	0.051	3.88
2004	1,145	16,690	0	-15,545	597,228	0.029	6.41
2005	1,153	33,499	0	-32,346	611,627	0.056	3.32
2006	1,149	32,137	0	-30,988	626,425	0.053	3.45
2007	1,145	38,281	0	-37,136	641,620	0.061	2.90
2008	299	21,840	0	-21,541	657,229	0.033	1.35

2009	611	38,362	0	-37,751	673,252	0.057	1.56
2010	554	38,338	0	-37,784	689,692	0.056	1.42
2011	545	50,468	0	-49,923	706,569	0.072	1.06
2012	n.a.	56,635	0	-56,635	723,868	0.078	n.a.
2013	n.a.	51,815	0	-51,815	741,500	0.069	n.a.

Sources: IMF, BBC, and FAOSTAT

Table S3. Wheat flour imports

Year	Production (Mt)	Import (Mt)	Export (Mt)	Net import (Mt)	Population	Consumption per capita (Mt/year)	Self- sufficiency ratio (%)
1991	0	2,624	0	-2,624	423,872	0.006	0
1992	0	3,617	0	-3,617	436,448	0.008	0
1993	0	3,767	0	-3,767	449,274	0.008	0
1994	0	3,910	0	-3,910	462,277	0.008	0
1995	0	3,872	0	-3,872	475,394	0.008	0
1996	0	3,970	0	-3,970	488,627	0.008	0
1997	0	3,633	0	-3,633	501,953	0.007	0
1998	0	3,084	0	-3,084	515,385	0.005	0
1999	0	3,417	0	-3,417	528,848	0.006	0
2000	0	3,295	0	-3,295	542,357	0.006	0
2001	0	7,183	0	-7,183	555,888	0.012	0
2002	0	3,620	0	-3,620	569,479	0.006	0
2003	0	7,473	0	-7,473	583,211	0.012	0
2004	0	8,368	0	-8,368	597,228	0.014	0
2005	0	6,518	0	-6,518	611,627	0.010	0
2006	0	8,730	0	-8,730	626,425	0.013	0
2007	0	8,453	0	-8,453	641,620	0.013	0
2008	0	7,066	0	-7,066	657,229	0.010	0
2009	0	9,219	0	-9,219	673,252	0.013	0
2010	0	9,575	0	-9,575	689,692	0.013	0
2011	0	10,193	0	-10,193	706,569	0.014	0
2012	0	10,687	0	-10,687	723,868	0.014	0
2013	0	12,377	0	-12,377	741,500	0.016	0

Sources: IMF, BBC, and FAOSTAT.

Table S4. Maize production and imports

Year	Production (Mt)	Import (Mt)	Export (Mt)	Net Export (Mt)	Population	Consumption per capita (Mt/year)	Self-sufficiency ratio (%)
1991	3,570	n.a.	0	0	423,872	0.008	100
1992	3,600	n.a.	0	0	436,448	0.008	100
1993	3,636	n.a.	0	0	449,274	0.008	100
1994	3,672	n.a.	0	0	462,277	0.007	100
1995	3,709	45	0	0	475,394	0.007	99
1996	3,700	11	0	0	488,627	0.007	100
1997	2,695	8	0	0	501,953	0.005	100
1998	2,690	25	0	0	515,385	0.005	99
1999	2,690	38	0	0	528,848	0.005	99
2000	2,685	75	0	0	542,357	0.005	97
2001	9,091	107	0	0	555,888	0.016	99
2002	9,146	34	0	0	569,479	0.016	100

2003	9,202	92	0	0	583,211	0.015	99
2004	9,258	151	0	0	597,228	0.015	98
2005	9,315	36	0	0	611,627	0.015	100
2006	9,371	106	0	0	626,425	0.015	99
2007	9,428	231	0	0	641,620	0.015	98
2008	11,580	81	0	0	657,229	0.017	99
2009	11,823	35	0	0	673,252	0.017	99
2010	12,473	211	0	0	689,692	0.018	98
2011	12,483	151	0	0	706,569	0.017	98
2012	5,461	124	0	0	723,868	0.007	100
2013	6,278	211	0	0	741,500	0.008	99

Sources: IMF, BBC, and FAOSTAT.

Table S5. Vegetables/onions, dry

Year	Production (Mt)	Import (Mt)	Export (Mt)	Net Production (Mt)	Population	Consumption per capita (Mt/year)	Self- sufficiency ratio (%)
1991	130	n.a.	n.a.	0	423,872	0.0003	100
1992	130	n.a.	n.a.	0	436,448	0.0002	100
1993	134	n.a.	n.a.	0	449,274	0.0002	100
1994	138	n.a.	n.a.	0	462,277	0.0002	100
1995	142	n.a.	n.a.	0	475,394	0.0002	100
1996	150	n.a.	n.a.	0	488,627	0.0003	100
1997	158	n.a.	n.a.	0	501,953	0.0003	100
1998	165	n.a.	n.a.	0	515,385	0.0003	100
1999	175	n.a.	n.a.	0	528,848	0.0003	100
2000	912	n.a.	n.a.	0	542,357	0.0016	100
2001	937	97	n.a.	840	555,888	0.0018	91
2002	1,479	297	n.a.	1,182	569,479	0.0031	83
2003	839	878	n.a.	-39	583,211	0.0029	49
2004	858	936	n.a.	-78	597,228	0.0030	48
2005	875	1095	n.a.	-220	611,627	0.0032	44
2006	894	1,189	n.a.	-295	626,425	0.0033	43
2007	912	836	n.a.	76	641,620	0.0027	52
2008	1,043	915	n.a.	128	657,229	0.0029	53
2009	1,095	954	n.a.	141	673,252	0.0030	53
2010	1,156	1,179	n.a.	-23	689,692	0.0033	50
2011	1,161	983	n.a.	178	706,569	0.0030	54
2012	241	1,127	n.a.	-886	723,868	0.0010	18
2013	251	1,716	n.a.	-1465	741,500	0.0026	13

Sources: IMF, BBC, and FAOSTAT.

Table S6. Vegetables/garlic

Year	Production (Mt)	Import (Mt)	Export (Mt)	Population	Consumption per capita (Mt/year)	Self-sufficiency ratio (%)
1991	n.a.	n.a.	n.a.	423,872	n.a.	0
1992	n.a.	n.a.	n.a.	436,448	n.a.	0

1993	n.a.	n.a.	n.a.	449,274	n.a.	0
1994	n.a.	n.a.	n.a.	462,277	n.a.	0
1995	n.a.	4	n.a.	475,394	0.000008	0
1996	n.a.	7	n.a.	488,627	0.000014	0
1997	n.a.	4	n.a.	501,953	0.000007	0
1998	n.a.	0	n.a.	515,385	0	0
1999	n.a.	16	n.a.	528,848	0.00003	0
2000	n.a.	11	n.a.	542,357	0.00002	0
2001	n.a.	18	n.a.	555,888	0.00003	0
2002	n.a.	45	n.a.	569,479	0.00007	0
2003	n.a.	155	n.a.	583,211	0.00026	0
2004	n.a.	145	n.a.	597,228	0.00024	0
2005	n.a.	124	n.a.	611,627	0.00020	0
2006	n.a.	173	n.a.	626,425	0.00027	0
2007	n.a.	239	n.a.	641,620	0.00037	0
2008	n.a.	294	n.a.	657,229	0.00044	0
2009	n.a.	174	n.a.	673,252	0.00025	0
2010	n.a.	234	n.a.	689,692	0.00033	0
2011	n.a.	330	n.a.	706,569	0.00046	0
2012	n.a.	300	n.a.	723,868	0.00041	0
2013	n.a.	526	n.a.	741,500	0.00070	0

Sources: FAOSTAT.

Table S7. Red meat/cattle, sheep and goat meat (frozen and live) production and imports

Year	Production (Mt)	Import (Mt)	Export (Mt)	Population	Consumption per capita (Mt/year)	Self-sufficiency ratio (%)
1991	1,123	1,640	0	423,872	0.0065	40
1992	1,086	3,682	0	436,448	0.0109	22
1993	1,115	3,154	0	449,274	0.0095	26
1994	1,115	3,249	0	462,277	0.0094	25
1995	1,215	2,600	0	475,394	0.0080	31
1996	1,160	3,406	0	488,627	0.0093	25
1997	1,065	3,246	0	501,953	0.0085	24
1998	1,306	4,294	0	515,385	0.0108	23
1999	1,574	3,512	0	528,848	0.0096	30
2000	1,978	4,233	0	542,357	0.0114	31
2001	2,000	4,294	0	555,888	0.0113	31
2002	2,607	4,182	0	569,479	0.0119	38
2003	2,151	4,537	0	583,211	0.0114	32
2004	2,607	5,819	0	597,228	0.0141	30
2005	2,700	6,226	0	611,627	0.0145	30
2006	2,858	6,028	0	626,425	0.0141	32
2007	2,822	6,210	0	641,620	0.0140	31
2008	1,704	6,210	0	657,229	0.0120	21
2009	1,579	6,210	0	673,252	0.0115	20
2010	1,717	6,210	0	689,692	0.0114	21
2011	1,526	6,210	0	706,569	0.0109	19
2012	1,745	6,200	0	723,868	0.0109	21
2013	1,551	6,087.25	0	741,500	0.0100	20

Sources: IMF, BBC, and FAOSTAT.

Table S8. Poultry meat/chicken meat production and import

Year	Production (Mt)	Import (Mt)	Population	Consumption per capita (Mt/year)	Self-sufficiency ratio (%)
1991	202	650	423,872	0.002	24
1992	186	570	436,448	0.001	25
1993	188	650	449,274	0.001	22
1994	190	800	462,277	0.002	19
1995	190	555	475,394	0.001	26
1996	192	882	488,627	0.002	18
1997	189	898	501,953	0.002	17
1998	190	781	515,385	0.001	20
1999	190	575	528,848	0.001	20
2000	192	932	542,357	0.002	17
2001	233	856	555,888	0.001	21
2002	266	1,761	569,479	0.003	13
2003	318	5,200	583,211	0.009	6
2004	166	5,353	597,228	0.009	3
2005	198	4,843	611,627	0.008	4
2006	205	4,794	626,425	0.007	4
2007	213	5,748	641,620	0.009	4
2008	544	5,596	657,229	0.009	9
2009	536	6,805	673,252	0.010	7
2010	568	10,923	689,692	0.016	5
2011	576	8,017	706,569	0.012	7
2012	576	12,700	723,868	0.018	4
2013	576	7,960	741,500	0.011	7

Sources: IMF and FAOSTAT.

Table S9. Poultry eggs, hen, in shell production and imports

Year	Production (Mt)	Import (Mt)	Population	Consumption per capita (kg/year)	Self-sufficiency ratio (%)
1991	1,024	0	423,872	2.42	99
1992	1,025	0	436,448	2.34	100
1993	1,058	0	449,274	2.35	100
1994	1,092	12	462,277	2.38	98
1995	1,125	1	475,394	2.36	99
1996	1,158	1	488,627	2.37	99
1997	1,172	6	501,953	2.34	99
1998	1,186	4	515,385	2.30	99
1999	1,201	6	528,848	2.28	99
2000	1,215	1	542,357	2.24	99
2001	1,229	0	555,888	2.21	100
2002	1,243	1	569,479	2.18	99
2003	1,257	11	583,211	2.17	99
2004	1,258	0	597,228	2.10	100
2005	1,259	0	611,627	2.05	100
2006	1,274	0	626,425	2.03	100
2007	1,288	0	641,620	2.00	100
2008	1,276	0	657,229	1.94	100
2009	1,277	0	673,252	1.89	100

2010	1,370	0	689,692	1.98	100
2011	1,404	0	706,569	1.98	100
2012	1,279	0	723,868	1.76	100
2013	1,282	304	741,500	2.13	80

Sources: IMF, BBC, and FAOSTAT.

Table S10. Dairy products (milk/ milk, whole dried; milk, whole condensed; milk, whole fresh cow; milk, skimmed cow; milk, skimmed dried; milk, whole evaporated) production and imports

Year	Production (Mt)	Import (Mt)	Population	Consumption per capita (kg/year)	Self-sufficiency ratio (%)
1991	11,245	1,180	423,872	29.31	90
1992	11,525	1,560	436,448	29.98	88
1993	11,804	840	449,274	28.14	93
1994	12,222	930	462,277	28.45	92
1995	12,261	718	475,394	27.30	94
1996	12,546	694	488,627	27.09	94
1997	12,808	784	501,953	27.07	94
1998	12,369	651	515,385	25.26	95
1999	12,510	531	528,848	24.65	96
2000	12,651	474	542,357	24.19	96
2001	13,847	485	555,888	25.78	94
2002	14,271	866	569,479	26.58	90
2003	12,241	1,231	583,211	23.09	92
2004	12,382	1,033	597,228	22.46	90
2005	12,523	1,329	611,627	22.64	95
2006	12,664	531	626,425	21.06	89
2007	13,244	1,489	641,620	22.96	94
2008	13,249	831	657,229	21.42	83
2009	13,254	2,658	673,252	23.63	92
2010	13,259	1,036	689,692	20.72	92
2011	14,623	3,664	706,569	25.88	79
2012	14,625	1,510	723,868	22.28	90
2013	14,628	3,972	741,500	25.08	78

Source: FAOSTAT.

Table S11. Sugar and sweets /sugar confectionery, sugar raw centrifugal, sugar refined imports

Year	Production (Mt)	Import (Mt)	Export (Mt)	Population	Consumption per capita (kg/year)	Self-sufficiency ratio (%)
1991	0	3,974	0	423,872	9.37	0
1992	0	3,939	0	436,448	9.02	0
1993	0	3,854	0	449,274	8.57	0
1994	0	3,629	0	462,277	7.85	0
1995	0	3,754	0	475,394	7.89	0
1996	0	3,751	0	488,627	7.67	0
1997	0	3,376	0	501,953	6.72	0
1998	0	3,056	0	515,385	5.92	0
1999	0	3,598	0	528,848	6.80	0
2000	0	2,345	0	542,357	4.32	0

2001	0	2,842	0	555,888	5.11	0
2002	0	4,147	0	569,479	7.28	0
2003	0	8,307	0	583,211	14.24	0
2004	0	9,474	0	597,228	15.86	0
2005	0	8,457	0	611,627	13.82	0
2006	0	10,344	0	626,425	16.51	0
2007	0	8,560	0	641,620	13.34	0
2008	0	7,376	0	657,229	11.22	0
2009	0	5,929	0	673,252	8.80	0
2010	0	6,654	0	689,692	9.64	0
2011	0	5,561	0	706,569	7.87	0
2012	0	4,853	0	723,868	6.70	0
2013	0	6,157	0	741,500	8.30	0

Source: FAOSTAT.

Table S12. Food items and expenditure elasticity for food demand in Comoros

Food group	Food items	Consumption per capita in 2013 (base year) (kg/year)	Elasticity of demand
Cereals	Wheat flour	16	0.57
	Maize	8	0.15
	Rice	69	0.36
Livestock	Red meat	10	1.4
	Poultry meat	11	0.28
	Eggs	2.13	0.75
Milk and Dairy products	Milk	25.08	0.82
Vegetables	Onions, dry	2.60	0.46
	Garlic	0.70	0.46
Sugar and sweets	Sugar	8.30	0.55

Sources: FAOSTAT, IMF, Central bank of Comoros, statistical data.

Table S13. Population and GDP projections in Comoros

Year	Population projection	Population in the base year (2013)	Average annual growth rate (%)	GDP growth rate (%)
		741,500		
2030	1,062,000		1.94	7.5

Sources: World Bank population data for the base year and UN population data for the population predictions in 2030.

Figures S1 and S2 illustrate the population and GDP trends in Comoros, from 2020 to 2030
 Figure S1 presents the population trends and projections in Comoros from 1991-2030

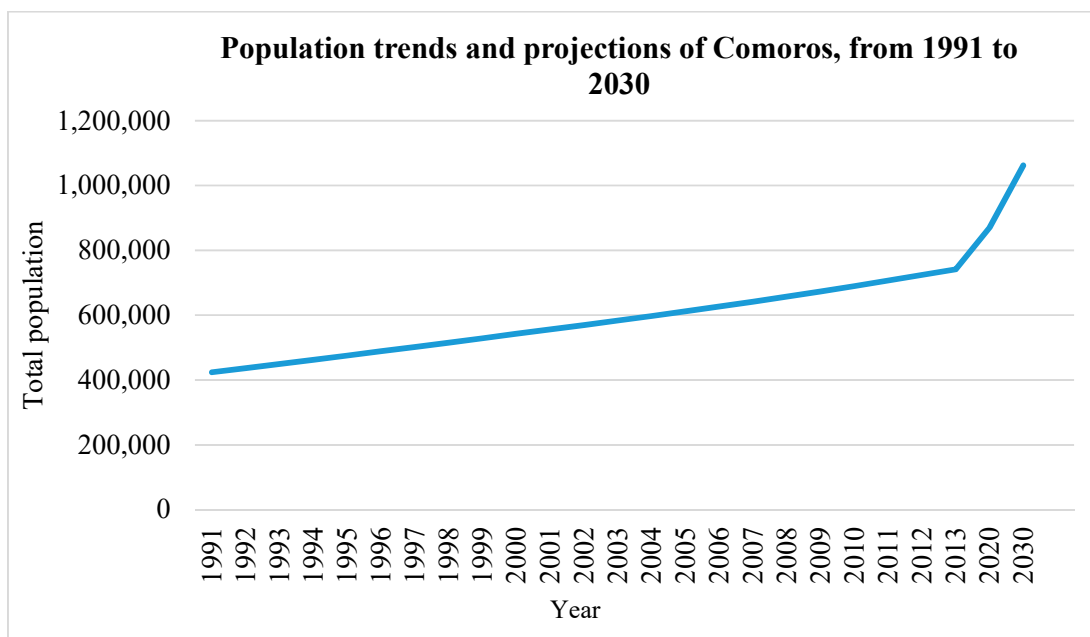


Figure S1. Current and predictions of the Comorian population

Sources: <https://data.worldbank.org/country/comoros> and
<https://population.un.org/wpp/Download/Standard/Population/>

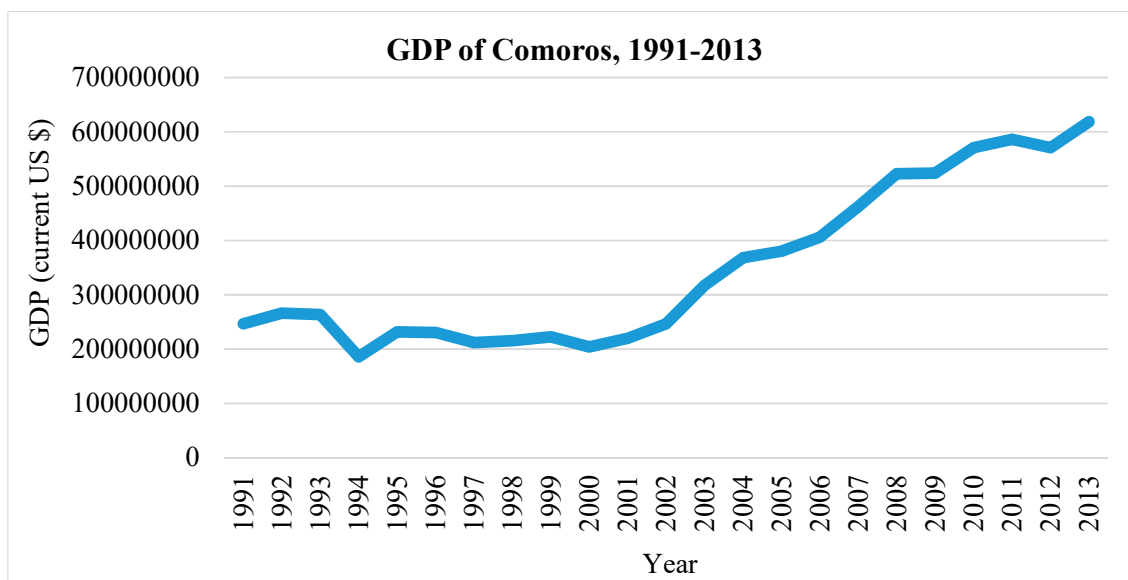


Figure S2. GDP estimates for Comoros, from 1991 to 2013

Source: <https://data.worldbank.org/country/comoros>

1.3. Supplementary results

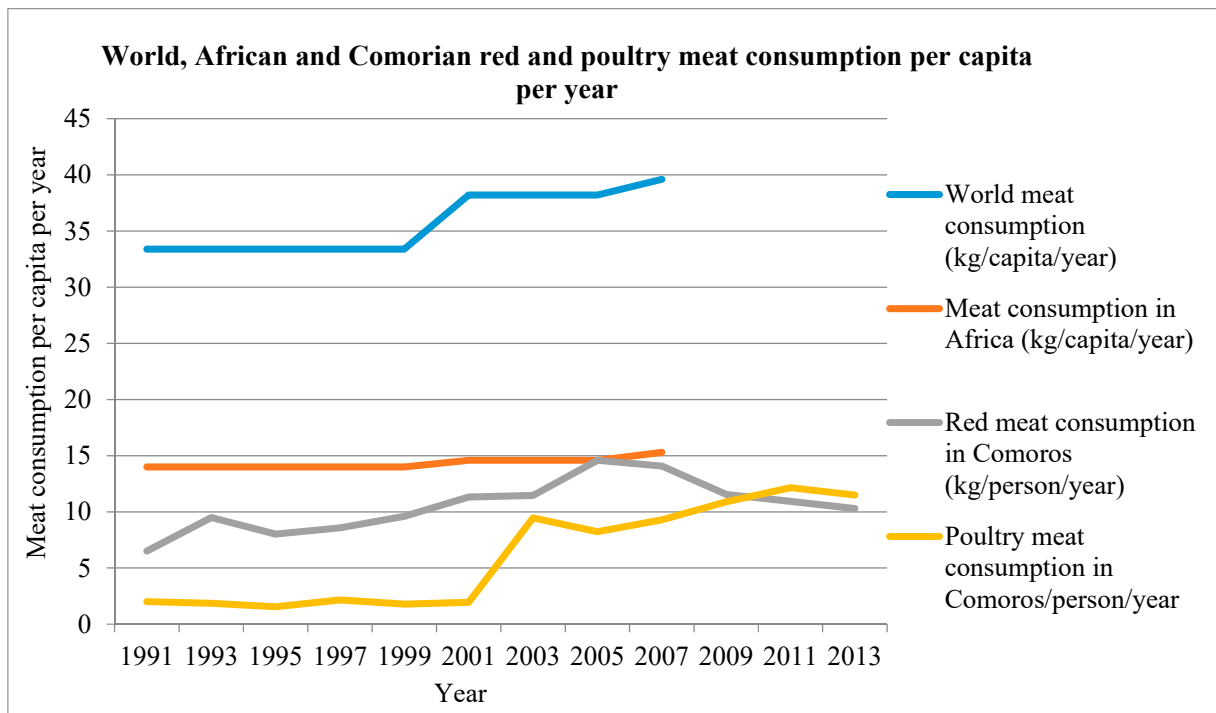


Figure S3. Comparison between the red and poultry meat consumption per capita per year in Comoros, in the world, and in African from 1991 to 2013. Values for the world and for Africa were from (Manitra et al. 2011)

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