Appendix A. Input data

Table A.1: National fertilizer consumption data in t yr^{-1} for the year 2014 as primary data for flow *F1.im1 mineral fertilizer* and mean and maximum deviation as used in the MFA. All values rounded to two significant digits.

	Kenya				Uganda			
	FAO (2019a) (moving average)	IFA (2019) (moving average)	Mean	Maximum deviation	FAO (2019a) (moving average)	Godfrey & Dickens (2015)	Mean	Maximum deviation
N	150,000	140,000	140,000	2,700	8,100	15,000	12,000	3,500
P	23,000	49,000	36,000	13,000	1,700	1,200	1,00	260
K	11,000	14,000	13,000	1,600	2,300	1,800	2,100	250

Table A.2: Literature values for nitrogen fixation of different crops, as well as mean and standard deviation as used in the MFA. All values rounded to two significant digits.

	Stoorvogel et al. (1990)	Wortmann & Kaizzi (1998)	Brady et al. (2008)	Lesschen et al. (2007)	Giller (2001)	Mean	SD	Ojiem et al. (2007)
	kg N ha^{-1}							% of N in plants
Beans	8.9	20	40	8.1	-	19	13	56
Peas	19	-	75	18	-	37	27	69
Soy beans	50	50	100	56	-	64	21	73
Other pulses	-	-	50	-	-	50	-	69
Nuts	15	-	60	16	-	31	21	70
Pasture	-	40	-	4.3	15	20	15	-

Appendix A.1. Soil erosion modeling

USLE model description

Soil erosion is the disruption of soil through the impact of external forces, such as kinetic energy induced by water or wind (Zachar, 1982). The Universal Soil Loss Equation (USLE; Wischmeier & Smith, 1978; Renard et al., 1997) is an empirical model for the estimation of long-term mean annual soil loss that results from water induced erosion. The long-term mean annual soil loss is calculated by the product of six USLE inputs that represent factors that influence the water erosion process.

$$A = R \times K \times LS \times C \times P, \tag{A.1}$$

where A is the long-term average annual soil loss in t ha^{-1} yr^{-1}, R is the rainfall erosivity that reflects the available kinetic energy to erode soil particles in MJ mm ha^{-1} h^{-1} yr^{-1}, K is the soil erodibility factor that expresses the resistance of the soil to be eroded in t h MJ^{-1} mm^{-1}, L and S are the unitless topographic factors slope length and the slope steepness that describe the influence of terrain properties on soil erosion, C is the unitless cover management factor that expresses the protection of the soil from being eroded by a plant cover, and P is the unitless support practice factor that describes the mitigation of soil loss due to specific farm management practices.

USLE input factors and uncertainties

In a soil erosion study for Kenya and Uganda, Schürz et al. (2020) analyzed the impact of the methods to calculate the USLE inputs on the uncertainties of the calculated soil loss. Schürz et al. (2020) applied well accepted and frequently implemented methods to calculate the USLE inputs R, K, LS, and C and in total generated 972 realizations of the USLE model to calculate spatially distributed soil loss estimates for Kenya and Uganda with a spatial resolution of 90 m. For the mountainous region of Mt. Elgon (that includes the present study area), Schürz et al. (2020) showed that the method to calculate the C factor had the strongest impact on the calculated soil loss uncertainties in the Sio-Malaba-Malakisi River Basin area (see Fig. 6 in Schürz et al. (2020)). Therefore, USLE model combinations that consider different C factor realizations were selected from Schürz et al. (2020) and implemented in this study. In total 3 different methods to calculate the C factor were considered that were also used in other recent erosion studies performed in east Africa (e.g. Fenta et al. (2020) who implemented the method of Panagos et al. (2015a) to calculate C from literature values and land cover, or Karamage et al. (2017) who implemented the method of Knijff et al. (2000) to calculate C from the NDVI). For the remaining USLE inputs R, K, and LS input realizations were used that were identified as plausible realizations in Schürz et al. (2020) and that were frequently implemented in other erosion studies. Table A.3 summarises the USLE model realizations that were implemented in this study.

Table A.3: USLE model setups and methods for the calculation of the USLE inputs. The labels of the USLE input factor realizations in this table refer to the realizations and the implemented methods and data sets as they are described in Schürz et al. (2020).

Nr.	R factor	K factor	LS factor	C factor
1	$R_{GloREDa}$	$K_{SG,Wischmeier}$	$LS_{SRTM,Desmet}$	$C_{NDVI,Rainyseason}$
2	$R_{GloREDa}$	$K_{SG,Wischmeier}$	$LS_{SRTM,Desmet}$	$C_{ESALC,Monfreda}$
3	$R_{GloREDa}$	$K_{SG,Wischmeier}$	$LS_{SRTM,Desmet}$	$C_{ESALC,administr.}$

This study focuses on soil loss from agricultural areas. Schürz et al. (2020), however, identified strong discrepancies between typical literature values for C factor values of agricultural land uses and the C factor values that were calculated for the southwest of Uganda when the method of Knijff et al. (2000) and MODIS NDVI are implemented. Therefore, the soil loss estimates from the USLE model that included the NDVI are implausibly low for agricultural areas in the study region. As a consequence, this USLE model realization was eventually excluded from all further analyses .

For the spatial units in the study area (district and county level) a mean soil loss from agricultural areas was calculated. Therefore, soil losses for agricultural land uses were extracted from the remaining 2 selected spatially distributed soil loss estimates. For all districts and counties the soil erosion from agricultural land uses was averaged by calculating the arithmetic mean soil loss.

Estimation of the support practice factor P for the current situation

Schürz et al. (2020) did not consider the support practice factor P in their analysis, as data on the implementation of soil conservation measures are limited, particularly on large spatial scales. This study extends the soil loss estimates from Schürz et al. (2020) with spatially distributed estimates for the P factor. For the study region, agricultural household survey data are available (Turinawe et al., 2018; Mwanake et al., in preperation). The household surveys also queried the application of typical soil conservation measures. The soil conservation measures from the questionnaire were harmonized and grouped or generalized into 4 main groups or classes ('generalized support practices' or gSP) based on a widely implemented classification scheme (e.g., Karamage et al., 2017; Panagos et al., 2015b; Terranova et al., 2009) that is illustrated in Table A.4.

Table A.4: Grouping of the soil conservation measures queried in the field questionnaires of Turinawe et al. (2018) and Mwanake et al. (in preperation) into 'generalized support practices' (gSP) and the corresponding support practices considered in Shin (1999).

Generalized support practice	Soil conservation measures from questionnaire survey		Support Practice (Shin, 1999)
	Turinawe et al. (2018)	Mwanake et al. (in preperation)	
linear	Trenches/Diversion channel Grass strips Fanya Chini Fanya Juu Hedges Alley cropping Stone/soil bands	Trenches Fanya Chini Fanya Juu Hedges Alley cropping Stone/soil bands	Strip cropping
extensive	Mulching Fallow Contour ploughing Minimum tillage Cover crops Intercropping	Mulching Fallow Contour ploughing Minimum tillage Cover crops Intercropping	Contouring
intensive		Terraces	Terracing

Given Table A.4, the share of the generalized support practices gSP, including the 'no practice' share, is known at every location where a farmer was interviewed. The shares thereby sum up to 100%. After quality control and data harmonisation, point data from 643 farmers from the five administrative units are available in total. Since spatially distributed P values are necessary (the study of Schürz et al. (2020) worked with a spatial resolution of 90 m) to be included in the existing USLE models, an interpolation of the point data is necessary, i.e. the estimation of the shares of gSPs at every location on the 90 m raster.

A correlation analysis showed that there was a dependency between the gSPs and the terrain slope. Additionally, it was evident, that the applied gSPs showed spatial dependency, namely that regional differences were already visible in the point data. Therefore, a spatial interpolation with Simple CoKriging (available in the Geostatistical Wizard in ArcGIS (ESRI, 2017)) was performed for the shares of the single gSPs, using slope as an additional variable. This exercise is repeated four times for the single gSPs and the 'no practice' case, resulting in four maps describing the spatial patterns of the generalized management practices applied by the farmers.

In Karamage et al. (2017), a relationship between slope classes, generalized support practice gSP and P is available. Therefore, the terrain slope (based on a digital elevation model (DEM), in our case we used the MERIT DEM (Yamazaki et al., 2019)), was resampled three times, resulting in three (one for every gSP) spatially distributed maps of P factors as a function of slope. With this information a weighted mean P_x factor can be calculated for every location x of the raster, applying

$$P_x = \frac{P_{l,x} \cdot w_{l,x} + P_{e,x} \cdot w_{e,x} + P_{i,x} \cdot w_{i,x} + P_{np,x} \cdot w_{np,x}}{\sum_{k=1}^{k=4} w_{k,x}}, \qquad \text{(A.2)}$$

where $P_{l,x}$, $P_{e,x}$, $P_{i,x}$, and $P_{np,x}$ are the P factor literature values for the *linear*, *extensive*, *intensive* and *no practice* support practice measure classes at a location x and $w_{l,x}$, $w_{e,x}$, $w_{i,x}$, and $w_{np,x}$ are their respective weight fractions at the same location x. Equation A.2 thereby considers the interpolated point information on the shares of the applied gSP acquired from the farmers and single P factors depending on terrain slope. By multiplying the mean P factor map with the USLE realisation from Schürz et al. (2020), the gross soil for the current situation, i.e. including the applied support practices, can be calculated.

Estimation of the support practice factor P reflecting widespread erosion reduction practices

The effects of the "widespread implementation of erosion reduction practices"-scenario (*Best management practices* (BMP)-scenario) on soil erosion is estimated by calculating an additional spatially distributed P factor, which is then used in the USLE model.

For the development of the BMP-scenario ('best-management farmers'), assumptions are necessary on how more effective support practice measures (reflected by the grouped gSPs) will be adopted by the farmers in order to reduce soil erosion. First, regional and local topographical characteristics, but also the cultural setting, customs and the farmers' knowledge is reflected in the potential increase in the adoption of more effective gSPs. It is also more likely that farmers implement practices that are already in use by other farmers in their proximity, since distance and mobility may be a limiting factor, when it comes to exchange of knowledge. A second assumption is that farmers have the potential to reduce soil erosion by implementing measures to an extent that is already practiced by 'best-management farmers'. This assumption accounts for farmers in the study area, who have the knowledge and technology and implement support practices in such an extent that soil erosion reduction is evident. A third assumption is, that under best management conditions a substantial number of farmers practice at least some erosion reduction practices and thus decreases the number of 'no-practice'-farmers.

Changes in the support practices and erosion reduction practices that are assumed to be implemented by the farmers are calculated based on interpolated harmonized point data from Mwanake et al. (in preperation) and Turinawe et al. (2018). The generalized support practices gSP- and 'no-practice' raster maps that were generated in the previous steps, form the basis for this analysis (Figure A.1 a)). For each location $x_{i,j}$ of each gSP layer, cumulative distribution functions (CDFs) were generated for their weights based on the neighbouring pixels in a 10km radius neighbourhood (Figure A.1 b)). This step represents the assumption that $gSPs$ are adopted, which are already in place in the surrounding neighbourhood. The 99$^{\text{th}}$ percentile weight value (and the 1$^{\text{st}}$ percentile in the case of 'no-practice') is estimated from the CDF. This percentile value is then assigned as the new weight for the gSP in the location $x_{i,j}$ (Figure A.1 c)). The gSP weight layers have a spatial resolution of 90 m. Thus, the 10 km radius encloses 9700 pixels from which the new weights are estimated. The procedure is repeated for all raster cells and gSP layers and is implemented with the Focal Statistics Tool that is available in ArcGIS ESRI (2017).

The calculated weight values for the three gSPs and the 'no-practise' case in each location x are normalized that their sum is again 1. Based on the newly calculated weights $w_{l,x}$, $w_{e,x}$, $w_{i,x}$, and $w_{np,x}$ for the BMP scenario, a

P factor map is calculated using Equation A.2. Implementing the updated P factor map in the USLE model and comparing the resulting gross erosion to the current conditions, allows to estimate a potential reduction in soil loss.

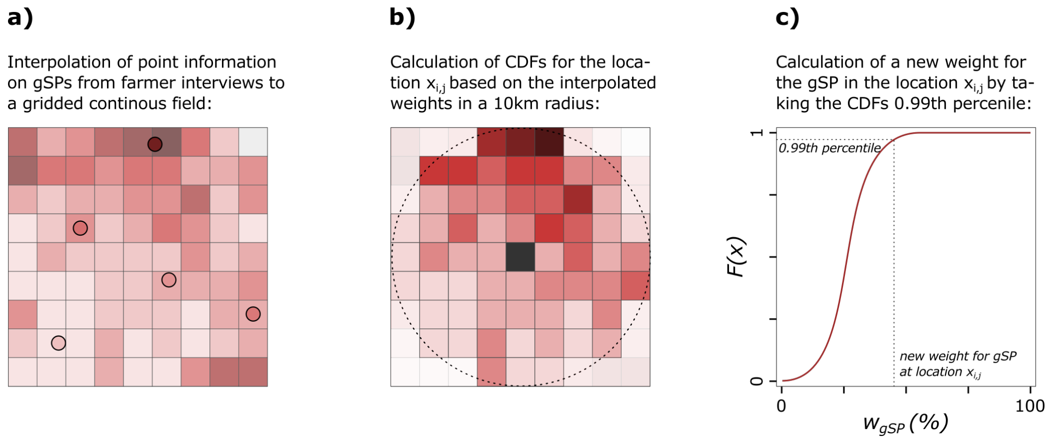

Figure A.1: Schematic workflow to calculate spatially distributed P factor estimates for the status quo and the BMP scenario.

Figure A.2 shows the cumulative distribution functions (CDFs) of the weights used for calculating the support practice P as a function of the $gSPs$ (different colored lines) for the BMP scenario 'best-management farmers' (dashed lines) and 'Status Quo' (solid lines). The comparison of the CDFs of the gSP weights between 'best-management farmers' and 'Status-Quo' indicate that no drastic changes result from taking the 99$^{\text{th}}$ and 1$^{\text{st}}$ percentiles. Reasons for that are i) that the gSP weights are limited by their surroundings, so that a newly calculated weight cannot exceed values in the surrounding neighbourhood and ii) the CDFs are highly skewed which results in comparatively low values for the 99$^{\text{th}}$ percentile. For the 'Status Quo' scenario, for example, the weight of 'no practice' (i.e. no erosion reduction measures in place) lies around 70% for the median. In 50% or more of the cases, the weight for 'no-practice' lies above 70%. Although the median value is reduced to 45% in the 'best-management farmers' scenario, there is still large space for improvement.

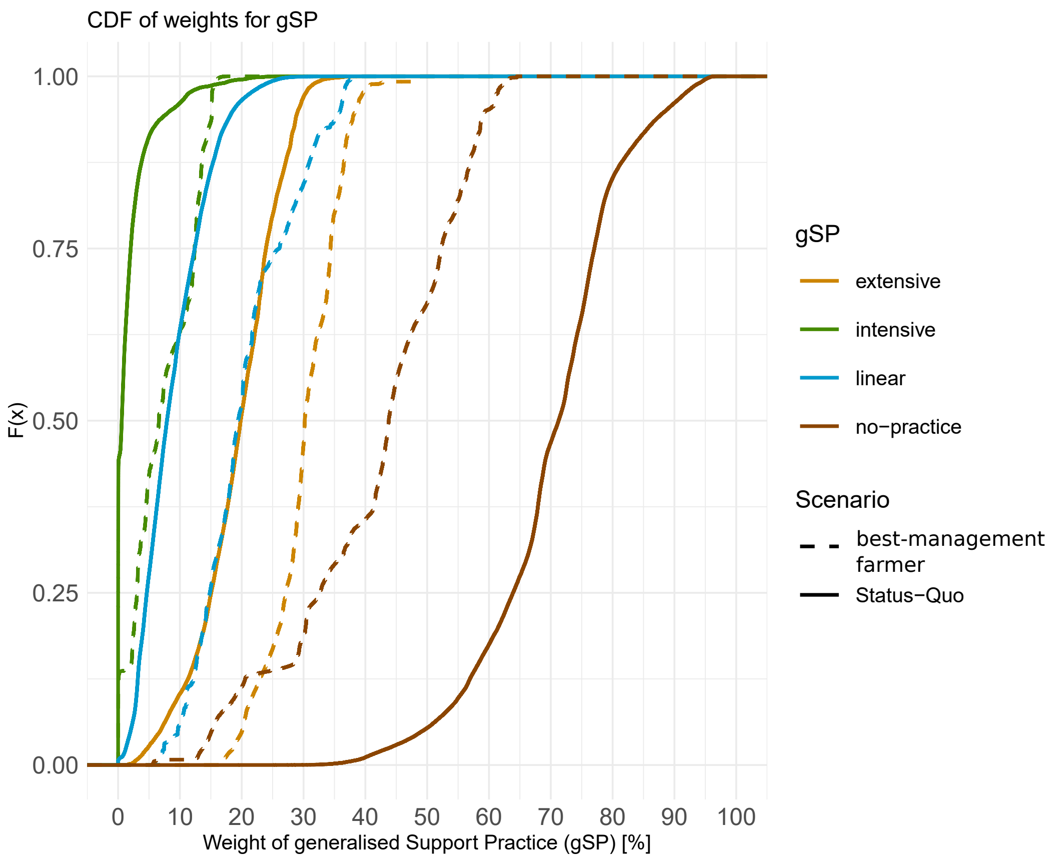

Figure A.2: Cumulative distribution function of weights used for the calculation of the support practices for the erosion reduction scenario.

It is important to stress that the CDFs are highly skewed. Accordingly, and even if the $99^{\text{th}}/1^{\text{st}}$ percentile is used, the erosion reduction due to the measures in the "ambitious" scenario is only around 20% for the different administrative units, as is shown in Table A.5.

Table A.5: Reduction rates of soil erosion per administrative unit as a result of the "ambitious farmer" support practice scenario compared to the Status Quo.

Administrative Unit	Change in soil erosion (%)
Bungoma	-19
Busia / KE	-23
Busia / UG	-23
Manafwa	-21
Tororo	-23

Table A.6: Distribution of slopes of agricultural land in % determined based on data from ESA (2017).

Slope category	Bungoma	Busia (KE)	Busia (UG)	Manafwa	Tororo
$\leq 5°$	78	92	100	24	99
$> 5° - \leq 10°$	15	7	0	45	1
$> 10°$	7	1	0	30	0

Table A.7: Soil nutrient concentrations in %, as well as mean values and SD or maximum deviation from mean as used in the MFA. All values rounded to two significant digits.

	Wortmann & Kaizzi (1998)	Makokha et al. (2001)	Blomme et al. (2005)	Ojiem et al. (2007)	Lederer et al. (2012)	Mean	SD (N) or maximum deviation (P & K)
N	0.14	0.25	0.15	0.16	0.13	0.17	0.043
P_{tot}	0.046	0.0073	-	-	-	0.027	0.019
K_{tot}	0.16	0.086	-	-	-	0.12	0.037

Table A.8: Enrichment factors from literature, as well as mean values and maximum deviation from mean as used in the MFA. All values rounded to two significant digits.

	Stoorvogel et al. (1990)	Wortmann & Kaizzi (1998)	Lesschen et al. (2007)	Mean	Maximum deviation
N	2.0	1.5	2.2	1.9	0.37
P	2.0	1.5	2.8	2.1	0.70
K	2.0	1.5	3.2	2.2	0.97

Table A.9: Comparison of official statistical data for crop areas from KNBS (2015a,b); UBOS (2010b) with estimated crop areas from the Soil and Water Conservation survey (Turinawe et al., 2018), as well as definition of chosen areas for the MFA in ha. All values rounded to two significant digits.

	Bungoma			Busia (KE)		
	KNBS (2015a)	Turinawe et al. (2018)	MFA value	KNBS (2015b)	Turinawe et al. (2018)	MFA value
Year	’13/14	’18	’14	’13/14	’18	’14
Maize	96000	70000	70000	19000	39000	39000
Millet	2400	620	2400	4200	4200	4200
Sorghum	2200	350	2200	3700	7900	7900
Other cereals	170	-	170	32	39	39
Rice	270	-	270	-	-	-
Cassava	580	4300	4300	9300	9100	9100
Sweet potatoe	5200	4500	5200	5000	4700	4700
Irish potatoe	-	-	-	-	-	-
Yam	-	-	-	-	-	-
Beans	64000	55000	64000	13000	16000	16000
Peas	-	420	420	-	200	200
Soybeans	-	1900	1900	-	420	420
Other pulses	210	250	210	-	20	20
Simsim	-	-	-	-	-	-
Other oil crops	960	8000	960	84	5600	5600
Tomatoes	1600	4600	1600	490	440	440
Cabbages	1200	620	1200	28	49	49
Onions	-	2800	2800	-	-	-
Other vegetables	22000	4800	22000	350	680	680
Banana/Matoke	3700	7200	7200	410	360	360
Mangoes	1200	-	1200	150	-	-
Fruits	4700	-	4700	190	-	-
Coffee	-	3900	3900	-	-	-
Pepper	-	120	120	-	64	64
Sugarcane	-	6500	6500	-	99	99
Cotton	-	-	-	-	710	710
Total area [ha]			200000			89000

Table A.9 continued

	Busia (UG)			Manafwa			Tororo		
	UBOS (2010b)	Turinawe et al. (2018)	MFA value	UBOS (2010b)	Turinawe et al. (2018)	MFA value	UBOS (2010b)	Turinawe et al. (2018)	MFA value
Year	'08/09	'18	'14	'08/09	'18	'14	'08/09	'18	'14
Maize	18000	17000	18000	11000	11000	11000	11000	23000	23000
Millet	1900	900	1900	670	370	670	12000	10000	10000
Sorghum	3400	1900	3400	110	14	200	7500	6500	7500
Other cereals	-	-	-	-	16	16	-	-	-
Rice	1400	160	1400	-	-	-	1800	9000	9000
Cassava	7600	8000	7600	1500	2500	2500	14000	21000	14000
Sweet potatoe	5200	3300	3300	2400	3000	2400	5200	9900	5200
Irish potatoe	-	-	-	1	-	-	150	-	150
Yam	-	720	720	-	-	-	-	280	280
Beans	3200	4300	4300	7200	8300	8300	1500	10000	8400
Peas	6	320	320	-	24	26	680	1200	1200
Soybeans	200	4600	4600	30	740	740	310	5100	3300
Other pulses	-	-	-	-	-	-	-	94	94
Simsim	280	-	280	-	-	55	660	-	660
Other oil crops	560	1700	1700	1300	3700	1300	4700	9400	9400
Tomatoes	-	560	560	-	80	80	-	960	960
Cabbages	-	47	47	-	40	40	-	94	94
Onions	-	-	-	-	240	240	-	1800	1800
Other vegetables	-	430	430	-	80	80	-	300	300
Banana/Matoke	120	480	480	4100	1500	6400	330	1200	330
Mangoes	-	-	-	-	-	-	-	-	-
Fruits	-	-	-	-	100	100	-	-	-
Coffee	-	88	88	-	1200	1200	-	110	110
Pepper	-	-	-	-	-	-	-	-	-
Sugarcane	-	58	58	-	240	240	-	-	-
Cotton	-	1900	1900	-	980	980	-	-	-
Total area [ha]			51000			36000			96000

Table A.10: Yields in t ha^{-1} yr^{-1} for different crops as used in the MFA. All values rounded to two significant digits.

	Kenya Oseko & Dienya (2015)	Bungoma KNBS (2015a)	Busia KNBS (2015b)	Uganda UBOS (2014)	Bukedi[1] UBOS (2020)	Elgon[2] UBOS (2020)	Busia Lederer et al. (2012)
Maize	1.7	2.4	2.8	2.4	3	1.8	2.1
Millet	2.9	0.67	0.61	1.3	0.78	1.1	0.98
Sorghum	2.8	1	0.61	0.8	0.82	-	0.51
Other cereals	2.9	-	-	1.6	2.2	1.7	-
Rice	4.3	1.8	2	2.5	-	-	-
Cassava	14	4.1	5.4	3.3	7.4	6	4.6
Sweet potatoe	15	3.6	4.3	4	6.1	4.4	3.8
Irish potatoe	12	-	8	4.6	-	-	-
Yam	12	-	-	-	-	-	-
Beans	0.63	0.72	1	1.5	0.58	0.93	0.58
Peas	4	-	-	0.5	-	-	1.2
Soybeans	-	0.65	0.78	0.6	-	-	1.6
Other pulses	1.8	-	-	-	0.5	-	-
Simsim	-	0.44	-	0.7	-	-	-
Other oil crops	-	0.75	0.92	0.7	1.2	-	0.37
Tomatoes	21	-	-	-	-	9	7
Cabbages	28	-	-	-	27	-	-
Onions	15	-	-	-	-	-	-
Other vegetables	15	-	-	-	10	8.3	-
Banana/Matoke	22	8.3	9.2	4.7	19	17	-
Mangoes	12	-	-	-	-	9.1	-
Fruits	12	-	-	-	9.2	-	-
Coffee	0.53	0.66	1	0.73	-	-	0.6
Sugarcane	27	-	-	-	-	-	-
Cotton	-	-	-	-	-	-	0.01

[1] Contains the districts Busia and Tororo

[2] Contains the district of Manafwa

Table A.11: N concentrations in g kg^{-1} wet weight for different crops, mean values and standard deviation as used in the MFA. All values rounded to two significant digits.

Product	FAO & GoK (2018)	USDA (2011)	Van den Bosch et al. (1998)	Wortmann & Kaizzi (1998)	Smaling et al. (1993)	Lentner (1981)	Stadlmayr et al. (2012)	Stoorvogel et al. (1990)	Mean	SD
Maize	13	16	16	11	9.3	5.8	16	17	13	3.6
Millet	12	19	21	-	-	2.7	18	19	15	6.3
Sorghum	16	19	15	15	-	-	-	15	16	1.5
Other cereal	19	19	17	13	-	3.9	18	17	15	4.9
Rice	12	12	-	-	-	13	13	12	12	0.47
Cassava	2.3	2.3	13	3.1	-	-	2	4.2	4.4	3.8
Sweet potatoe	2.7	2.7	9.3	6	4.6	2.8	2.5	4.8	4.4	2.2
Irish potatoe	3.8	3.3	7.1	-	-	3.5	3.2	4.4	4.2	1.4
Yam	3	2.8	9.7	4.6	-	3.2	-	4.6	4.6	2.4
Beans	33	30	29	33	17	14	37	20	27	8
Peas	37	40	32	35	-	11	35	20	30	9.9
Soy beans	54	60	-	52	-	57	53	62	56	3.6
Other pulses	41	35	31	34	-	12	36	20	30	9.4
Simsim	24	28	-	-	-	-	-	30	27	2.3
Nuts	29	43	31	-	-	44	34	37	36	5.7
Tomatoes	1.6	5.1	0.6	-	-	1.8	1.7	9	3.3	2.9
Cabbages	1.8	-	-	-	-	-	-	-	1.8	-
Onions	2.4	15	1	-	-	2.5	1.8	9	5.3	5.1
Other vegetables	1.1	10	0.78	-	-	2.3	-	9	3.9	4.1
Bananas	2.2	2.2	-	2.6	-	1.8	2	0.7	1.9	0.6
Mangoes	0.96	-	-	-	-	-	-	-	0.96	-
Fruits	1.5	1.4	-	-	-	1.3	-	2	1.2	0.67
Coffee	26	23	24	15	5.9	-	-	35	21	9.1
Pepper	16	1.6	-	-	-	2	3.2	9	6.4	5.7
Sugarcane	0.16	6.6	10	-	6.1	-	-	0.6	3.4	3.8
Cotton	-	54	-	25	-	-	-	19	33	15
Beef	32	20	8.7	30	-	33	37	-	27	9.5
Poultry meat	30	19	11	30	-	32	28	-	25	7.5
Goat meat	31	21	7.3	30	-	32	30	-	25	8.8
Mutton	-	-	-	-	-	-	-	-	-	-
Pork	30	17	4	30	-	27	28	-	23	9.5
Cow milk	5.3	3	0.59	6	0.6	5.3	5.7	-	3.8	2.2
Goat milk	-	-	-	-	-	-	-	-	-	-
Eggs	20	13	-	-	-	21	21	-	19	3.4
Fish	27	20	-	-	-	31	31	-	27	4.5
Honey	0.64	-	-	-	-	-	-	-	0.64	-

Table A.12: P concentrations in g kg^{-1} wet weight for different crops, mean values and standard deviation as used in the MFA. All values rounded to two significant digits.

Product	FAO & GoK (2018)	USDA (2011)	Van den Bosch et al. (1998)	Wortmann & Kaizzi (1998)	Smaling et al. (1993)	Lentner (1981)	Stadlmayr et al. (2012)	Stoorvogel et al. (1990)	Mean	SD
Maize	2.9	2.1	1.5	1	3.4	1.1	2.5	3.4	2.2	0.91
Millet	1.8	2.9	2.2	-	-	3.1	3.1	4.1	2.9	0.73
Sorghum	3.3	2.9	2.1	2.5	-	-	-	5.5	3.2	1.2
Other cereal	2.1	2.7	1.9	1.8	-	2.6	3.1	4.4	2.7	0.86
Rice	1.4	1.2	-	-	-	2.2	2.8	3.4	2.2	0.84
Cassava	0.24	0.27	0.76	0.8	-	-	0.47	0.48	0.5	0.22
Sweet potatoe	0.25	0.47	0.89	1	0.3	0.47	0.51	0.79	0.58	0.26
Irish potatoe	0.81	0.57	0.49	-	-	0.53	0.5	1.3	0.7	0.3
Yam	0.61	0.44	0.73	0.9	-	0.5	-	0.31	0.58	0.19
Beans	6	3	2.3	2.8	2.7	1.4	4.3	3.4	3.2	1.3
Peas	2.7	3.7	2.3	3	-	1.2	3.9	3.4	2.9	0.86
Soy beans	3.8	7	-	4.5	-	5.5	4.7	11	6.1	2.4
Other pulses	3.1	3.3	2.3	2.9	-	1.3	4.1	3.4	2.9	0.83
Simsim	8	6.3	-	-	-	-	-	6.2	6.8	0.85
Nuts	1.9	3.8	2.1	-	-	4.1	4	6	3.6	1.4
Tomatoes	0.25	0.24	0.057	-	-	0.27	0.37	0.92	0.35	0.27
Cabbages	0.4	-	-	-	-	-	-	-	0.4	-
Onions	0.4	0.29	0.098	-	-	0.36	0.39	0.92	0.41	0.25
Other vegetables	0.25	0.27	0.074	-	-	0.28	-	0.92	0.3	0.3
Bananas	0.29	0.34	-	0.1	-	0.28	0.34	0.088	0.24	0.11
Mangoes	0.17	-	-	-	-	-	-	-	0.17	-
Fruits	0.26	0.16	-	-	-	0.19	-	0.22	0.17	0.09
Coffee	3.2	3	1.5	2	0.4	-	-	2.6	2.1	0.97
Pepper	1.9	0.26	-	-	-	0.25	0.43	0.92	0.75	0.62
Sugarcane	0.22	1.2	1.3	-	0.9	0.19	-	0.22	0.58	0.51
Cotton	-	8	-	2	-	-	-	9.8	6.6	3.3
Beef	2.8	2	2.3	2	-	2	1.7	-	2.1	0.35
Poultry meat	2.4	1.5	2.2	2	-	1.8	1.4	-	1.9	0.37
Goat meat	2.8	1.9	1.7	2	-	1.8	1.5	-	1.9	0.4
Mutton	-	-	-	-	-	-	-	-	-	-
Pork	2.5	1.9	2	2	-	2	1.7	-	2	0.26
Cow milk	1.2	0.8	0.12	0.9	0.09	0.89	0.92	-	0.71	0.4
Goat milk	-	-	-	-	-	-	-	-	-	-
Eggs	1.8	2	-	-	-	2.1	2	-	2	0.094
Fish	2.1	2	-	-	-	2	2.6	-	2.2	0.25
Honey	0.04	-	-	-	-	-	-	-	0.04	-

Table A.13: K concentrations in g kg^{-1} wet weight for different crops, mean values and standard deviation as used in the MFA. All values rounded to two significant digits.

Product	FAO & GoK (2018)	USDA (2011)	Van den Bosch et al. (1998)	Wortmann & Kaizzi (1998)	Smaling et al. (1993)	Lentner (1981)	Stadlmayr et al. (2012)	Stoorvogel et al. (1990)	Mean	SD
Maize	2.9	2.9	12	6.2	3.6	3	3.1	3.4	4.7	3.1
Millet	5.4	2	15	-	-	4.3	3.8	4.7	5.8	4.1
Sorghum	3.1	3.5	6.6	2.4	-	-	-	3.7	3.9	1.4
Other cereal	3.6	3	11	4.3	-	3.4	3.7	4.8	4.9	2.7
Rice	0.59	1.2	-	-	-	1.5	2.5	3.4	1.8	1
Cassava	2.7	2.7	8.4	7.2	-	-	2.7	4.2	4.7	2.3
Sweet potatoe	3.9	3.4	7.3	7	2.9	5.3	4.6	7.3	5.2	1.7
Irish potatoe	6.5	4.2	6.4	-	-	4.1	5.5	6.9	5.6	1.1
Yam	3	3.4	7.6	7.1	-	4.7	-	2.9	4.8	1.9
Beans	8.7	13	18	11	8.1	6.5	16	11	12	3.7
Peas	13	9.8	18	1.6	-	3.7	12	11	9.9	5.2
Soy beans	17	18	-	11	-	19	17	20	17	2.9
Other pulses	8.5	12	18	6.3	-	5.1	14	11	11	4.2
Simsim	3.2	4.7	-	-	-	-	-	6.7	4.9	1.4
Nuts	13	7.1	17	-	-	7.4	7.3	8.1	10	3.8
Tomatoes	1.3	2.4	0.54	-	-	2.7	2.2	2.6	1.9	0.78
Cabbages	3.1	-	-	-	-	-	-	-	3.1	-
Onions	1.5	1.5	0.93	-	-	1.3	1.8	2.6	1.6	0.51
Other vegetables	2.5	1.9	0.71	-	-	2.3	-	2.6	1.7	0.97
Bananas	3.2	5	-	9	-	3.7	5	3.4	4.9	2
Mangoes	1.9	-	-	-	-	-	-	-	1.9	-
Fruits	2.4	1.9	-	-	-	2.5	-	2	1.8	0.9
Coffee	37	35	20	24	5.6	-	-	17	23	11
Pepper	5.8	3.1	-	-	-	2.1	3.3	2.6	3.4	1.3
Sugarcane	1.5	8.7	9.7	-	15	2.3	-	1.2	5.4	5.2
Cotton	-	14	-	7	-	-	-	9	9.8	2.7
Beef	2.3	3	0.58	3	-	3.8	3.6	-	2.7	1.1
Poultry meat	1.5	1.9	0.37	3	-	3.6	1.8	-	2	1
Goat meat	2.4	3.9	0.58	3	-	3.6	3.9	-	2.9	1.1
Mutton	-	-	-	-	-	-	-	-	-	-
Pork	0.58	2.9	0.4	3	-	2.9	3	-	2.1	1.2
Cow milk	1.4	1.3	0.24	2	0.2	1.4	1.5	-	1.1	0.62
Goat milk	-	-	-	-	-	-	-	-	-	-
Eggs	1.3	1.4	-	-	-	1.4	1.4	-	1.4	0.058
Fish	3.7	2.7	-	-	-	2.4	3.5	-	3.1	0.54
Honey	0.75	-	-	-	-	-	-	-	0.75	-

Table A.14: Residue to product ratio for different crops as used in the MFA. All values rounded to two significant digits.

	Lal (1995)	Okello et al. (2013)	Mean	Maximum Deviation
Maize	1	2	1.5	0.5
Millet	1.5	1.4	1.5	0.069
Sorghum	1.5	1.4	1.5	0.05
Other cereal	1.5	1.4	1.5	0.05
Rice	1.5	0.45	0.98	0.53
Cassava	0.25	0.4	0.33	0.075
Sweet potatoe	0.25	0.4	0.33	0.075
Irish potatoe	0.25	0.4	0.33	0.075
Yam	0.25	0.4	0.33	0.075
Beans	1	1.4	1.2	0.2
Peas	1	1.4	1.2	0.2
Soy beans	1	2.7	1.8	0.83
Other pulses	1	1.4	1.2	0.2
Simsim	1.5	2	1.8	0.25
Nuts	1.5	2.1	1.8	0.3
Bananas	-	2	1.5	0.5
Coffee	-	1	0.5	0.5
Sugarcane	0.25	0.25	0.25	-
Cotton	1.5	2.1	1.8	0.3

Table A.15: Nutrient concentrations in g kg^{-1} wet weight for different crop residues from literature as well as mean values and maximum deviation from mean as used in the MFA. All values rounded to two significant digits.

	Schreinemachers (2006)			Stoorvogel et al. (1990)			Mean			Maximum Deviation		
	N	P	K	N	P	K	N	P	K	N	P	K
Maize	6	1	15	9.7	1.9	21	7.9	1.5	18	1.9	0.47	3.2
Millet	13	1.5	18	20	4	59	16	2.8	39	3.9	1.3	21
Sorghum	8	1.5	17	11	4.6	29	9.4	3.1	23	1.4	1.6	6
Other cereal	8.9	1.3	17	11	2.2	27	9.9	1.8	22	1	0.46	5.3
Rice	-	-	-	11	2.3	21	11	2.3	21	-	-	-
Cassava	4.6	0.9	1.4	4.6	0.92	1.4	4.6	0.91	1.4	-	0.012	0.0055
Sweet potatoe	10	2	5	2.1	1.2	3.2	6.1	1.6	4.1	4	0.41	0.88
Irish potatoe	10	2	5	2.3	0.7	4.5	6.2	1.4	4.7	3.9	0.65	0.26
Yam	8.2	1.6	3.8	1.9	0.48	3.1	5.1	1.1	3.4	3.2	0.57	0.36
Beans	8	1.2	8	10	1	13	9.2	1.1	11	1.2	0.094	2.5
Peas	8	1.2	8	10	1	13	9.2	1.1	11	1.2	0.094	2.5
Soy beans	12	1.2	9.4	18	3	14	15	2.1	12	2.7	0.9	2.5
Other pulses	8	1.2	8	10	1	13	9.2	1.1	11	1.2	0.094	2.5
Simsim	12	1.2	9.4	15	5.5	21	14	3.3	15	1.4	2.1	5.8
Nuts	12	1.2	9.4	16	2.4	15	14	1.8	12	1.9	0.61	2.7
Tomatoes	-	-	-	3.2	1.4	7.8	3.2	1.4	7.8	-	-	-
Cabbages	-	-	-	3.2	1.4	7.8	3.2	1.4	7.8	-	-	-
Onions	-	-	-	3.2	1.4	7.8	3.2	1.4	7.8	-	-	-
Other vegetables	-	-	-	3.2	1.4	7.8	3.2	1.4	7.8	-	-	-
Bananas	1.6	0.3	12	1.2	0.31	6.4	1.4	0.3	9.1	0.2	0.004	2.8
Mangoes	-	-	-	0.6	0.22	4.4	0.6	0.22	4.4	-	-	-
Fruits	-	-	-	1.8	0.22	4.9	1.8	0.22	4.9	-	-	-
Coffee	-	-	-	4.3	3.8	9.2	4.3	3.8	9.2	-	-	-
Pepper	-	-	-	3.2	1.4	7.8	3.2	1.4	7.8	-	-	-
Sugarcane	-	-	-	0.3	0.31	0.33	0.3	0.31	0.33	-	-	-
Cotton	12	1.2	9.4	14	6.1	30	13	3.7	20	0.85	2.5	10

Table A.16: Comparison of estimates from official statistical data for animal numbers (no.) as well as mean values and maximum deviation from mean as used in the MFA. All values rounded to two significant digits.

	Kenya	Bungoma				
	FAO (2020a) mean ’13 – ’15	KNBS (2010)[1]	Turinawe et al. (2018)[1]	GoK & KNBS (2015)[1]	Mean	Maximum Deviation
Cattle	18000000	380000	600000	390000	460000	140000
Poultry	41000000	1400000	2200000	1700000	1800000	450000
Goat	26000000	-	200000	90000	130000	71000
Sheep	17000000	-	32000	71000	70000	37000
Pigs	440000	-	17000	-	17000	280
Others	-	-	-	10000	23000	13000

Table A.16 continued

	Busia (KE)					
	KNBS (2010)[1]	KNBS (2015b)	Turinawe et al. (2018)[1]	GoK & KNBS (2015)[1]	Mean	Maximum Deviation
Cattle	180000	190000	330000	230000	230000	99000
Poultry	1000000	890000	1200000	1100000	1000000	160000
Goat	-	66000	86000	76000	82000	16000
Sheep	-	56000	17000	23000	33000	23000
Pigs	-	63000	44000	-	54000	10000
Others	-	-	-	910	3300	2400

Table A.16 continued

	Uganda		Busia (UG)				
	UBOS (2010a) '08/'09	UBOS (2017) yearly increase '09 – '14	UBOS (2010a)[2]	Turinawe et al. (2018)[1]	UBOS & ICF (2018)[1]	Mean	Maximum Deviation
Cattle	11000000	3.2 %	31000	45000	34000	37000	8300
Poultry	37000000	6.4 %	540000	380000	240000	390000	160000
Goat	12000000	1.9 %	80000	68000	48000	65000	17000
Sheep	3400000	1.9 %	3200	3500	270	2300	2000
Pigs	3200000	1.9 %	16000	29000	-	22000	6900
Others	-	-	-	-	-	-	-

Table A.16 continued

	Manafwa					
	UBOS (2016)[1]	UBOS (2010a)[2]	Turinawe et al. (2018)[1]	UBOS & ICF (2018)[1]	Mean	Maximum Deviation
Cattle	53000	87000	89000	85000	78000	26000
Poultry	550000	590000	340000	270000	440000	170000
Goat	61000	85000	47000	70000	66000	19000
Sheep	-	5100	4600	230	3300	3100
Pigs	14000	41000	28000	10000	23000	18000
Others	1800	-	-	-	1800	-

Table A.16 continued

	Tororo					
	UBOS (2016)[1]	UBOS (2010a)[2]	Turinawe et al. (2018)[1]	UBOS & ICF (2018)[1]	Mean	Maximum Deviation
Cattle	42000	130000	120000	88000	95000	52000
Poultry	640000	800000	650000	650000	690000	110000
Goat	95000	160000	110000	130000	120000	37000
Sheep	14000	14000	940	6500	8800	7900
Pigs	32000	47000	67000	2500	37000	35000
Others	-	-	-	1500	1500	-

[1]Projected to 2014 with household numbers

[2]Projected to 2014 with yearly increase of national data from UBOS (2017)

Table A.17: Comparison of estimates of yearly production of animal products in 2014 from official statistical data, as well as definition of chosen values for the MFA. All values rounded to two significant digits.

		Unit	Kenya	Bungoma				Busia (KE)		
			FAO (2020b) mean '13 – '15	KNBS (2015a)	ASDSP et al. (2014)	FAO (2020a)	MFA value	KNBS (2015b)	FAO (2020a)	MFA value
Meat	Cattle	t yr^{-1}	450000	1900	-	11000	11000	6800	5800	6800
	Poultry	t yr^{-1}	24000	19000	2400	1000	1000	760	610	760
	Goats	t yr^{-1}	65000	110	-	320	110	260	210	260
	Sheep	t yr^{-1}	37000	76	-	150	76	220	71	220
	Pigs	t yr^{-1}	20000	6.5	-	790	790	1100	2500	1100
Milk	Cow	l yr^{-1}	3500000	35000	-	88000	35000	15000	45000	15000
	Goats	l yr^{-1}	270000	93	-	1300	1300	290	860	290
Eggs	Chicken	t yr^{-1}	77000	-	2100	3300	2100	430	2000	430

Table A.17 continued

		Unit	Uganda	Busia (UG)			Manafwa			Tororo		
			FAO (2020b) mean '13 – '15	UBOS (2010a)	FAO (2020a)	MFA value	UBOS (2010a)	FAO (2020a)	MFA value	UBOS (2010a)	FAO (2020a)	MFA value
Meat	Cattle	t yr^{-1}	210000	-	480	480	-	1400	1400	-	2200	2200
	Poultry	t yr^{-1}	62000	-	650	650	-	740	370	-	980	980
	Goats	t yr^{-1}	36000	-	210	210	-	230	120	-	450	450
	Sheep	t yr^{-1}	9400	-	8	8	-	13	6.6	-	36	36
	Pigs	t yr^{-1}	120000	-	520	520	-	1400	710	-	1700	1700
Milk	Cow	l yr^{-1}	1500000	1000	3600	1000	5900	10000	5900	5400	16000	5400
	Goats	l yr^{-1}	-	-	-	-	-	-	-	-	-	-
Eggs	Chicken	t yr^{-1}	46000	390	480	390	680	540	680	590	720	590

Table A.18: Dry matter excretion rates of animals in kg yr^{-1} from literature as well as mean values and standard deviation as used in the MFA. All values rounded to two significant digits.

	Williams (2010)	Onduru et al. (2008)	Fernandez-Rivera et al. (1995)	Ngwabie et al. (2018)	Castellanos-Navarrete et al. (2015)	Rufino et al. (2007)	Mean	Maximum Deviation
Cattle	-	1000	870	-	680	660	810	210
Poultry	11	-	-	-	-	-	11	-
Goat	-	73	72	-	-	-	72	0.55
Sheep	-	73	130	-	-	-	99	26
Pigs	-	410	-	330	-	-	370	39

Table A.19: Nutrient concentrations in animal faeces in g kg^{-1} dry matter from literature as well as mean values and standard deviation as used in the MFA. All values rounded to two significant digits.

Element	Animal	Sanginga et al. (2009)	Woomer et al. (1999)	Onduru et al. (2008)	Zhu et al. (2020)	Sileshi et al. (2017)	Mean	SD
Nitrogen	Cattle	15	14	14	16	12	14	1.2
	Poultry	29	31	-	-	19	26	5.2
	Goat	15	15	-	20	16	16	1.9
	Sheep	13	15	-	27	16	18	5.6
	Pigs	2	14	-	-	20	12	7.5
Phosphorus	Cattle	5.4	2	5.3	-	4	4.2	1.4
	Poultry	16	4.2	-	-	13	11	4.9
	Goat	4	2	-	-	3	3	0.82
	Sheep	4.7	2	-	-	3	3.2	1.1
	Pigs	12	2.3	-	-	9	7.7	4
Potassium	Cattle	6.4	24	15	-	12	14	6.3
	Poultry	23	24	-	-	9	19	6.7
	Goat	5.3	33	-	-	8	15	13
	Sheep	58	33	-	-	8	33	20
	Pigs	4.9	20	-	-	1	8.7	8.3

Table A.20: Share of nutrients excreted in urine from CAST (1996) given in %, as used in the MFA. All values rounded to two significant digits.

Animal	N	P	K
Cattle	50	5	70
Poultry	0	0	0
Goat	60	10	85
Sheep	60	10	85
Pigs	30	20	50

Table A.21: National food supply for 2013 in kg cap^{-1} yr^{-1} from FAO (2019b,c) as well as regional adjustment factors as used in the MFA determined using data from WFP-VAM (2009); GoK & KNBS (2015) and animal numbers from Table A.16 and UBOS (2010a). All values rounded to two significant digits.

		Kenya	Uganda	Bungoma	Busia (KE)	Busia (UG)	Manafwa	Tororo
		FAO (2019b,c)		GoK & KNBS (2015)		WFP-VAM (2009)		
		National food supply		Adjustment factors				
Group	Type	kg cap^{-1} yr^{-1}		-				
Plant products	Maize	76	48	1.1	0.86	0.86	1.3	1.3
	Millet	1	5.2	1.1	0.86	1.7	2.6	2.6
	Sorghum	2.4	2.7	1.1	0.86	0.75	2.1	2.1
	Other cereal	35	12	1.1	0.86	1	1	1
	Rice	12	4.9	1.1	0.86	1.5	1.3	1.3
	Cassava	22	75	0.82	0.99	0.72	0.79	0.79
	Sweet potatoe	21	48	0.82	0.99	1.6	0.82	0.82
	Irish potatoe	50	4	0.82	0.99	1.6	0.82	0.82
	Yam	0.2	-	0.82	0.99	1	1	1
	Beans	11	22	0.8	0.83	1.3	1.9	1.9
	Peas	0.55	0.21	0.8	0.83	1.3	1.9	1.9
	Soy beans	0.24	0.75	0.8	0.83	1.3	1.9	1.9
	Other pulses	4.3	0.69	0.8	0.83	1.3	1.9	1.9
	Simsim	0.33	2	0.8	0.83	0.55	0.69	0.69
	Nuts	1.7	4	0.8	0.83	0.55	0.69	0.69
	Tomatoes	9.6	0.89	0.88	0.83	3.2	3.1	3.1
	Cabbages	-	-	1.2	0.76	3.2	3.1	3.1
	Onions	1.9	4.9	0.88	0.83	3.2	3.1	3.1
	Other vegetables	37	22	0.88	0.83	3.2	3.1	3.1
	Bananas	28	120	0.57	0.45	0.68	0.32	0.32
	Mangoes	-	-	0.72	1	0.68	0.32	0.32
	Fruits	30	2.2	0.72	1	0.68	0.32	0.32
	Coffee	0.075	0.29	1	1	1	1	1
	Pepper	0.065	0.075	1	1	1	1	1
	Sugarcane	46	15	1.1	0.77	1.1	1.2	1.2
Others	Fish	4.2	12	1.4	2.7	1.4	1	1
	Honey	0.27	-	1.1	0.77	1	1	1
		FAO (2019b,c)		Table A.16, FAO (2020a)		UBOS (2010a)		
Meat	Cattle	9.5	5.2	0.75	1.1	0.25	0.66	0.7
	Poultry	0.53	1.7	1.3	1.6	1.1	1.2	1.1
	Goat and sheep	1.9	1.2	0.15	0.37	0.63	0.63	0.83
	Pigs	0.27	3.3	1.2	0.95	0.48	1.2	0.95
Milk	Cow and goat	96	37	0.75	1.1	0.25	0.66	0.7
Eggs	Chicken	1.8	0.97	1.3	1.6	1.1	1.2	1.1

Table A.22: Nutrient concentrations in organic waste in g kg^{-1} dry matter from literature as well as mean values and maximum deviation as used in the MFA. All values rounded to two significant digits.

	Amoding (2007)	Komakech et al. (2014)	Lederer et al. (2015)	Mean	Maximum deviation
N	16	22	14	17	4.6
P	2.1	3	5.2	3.4	1.8
K	30	29	37	32	5.2

Table A.23: National protein supply for 2013 in g cap^{-1} d^{-1} from FAO (2019b,c) as used in the MFA. All values rounded to two significant digits.

Group	Type	Kenya	Uganda
		FAO (2019b,c)	
Plant products	Maize	17	9.6
	Millet	0.18	0.64
	Sorghum	0.56	0.73
	Other cereal	7.7	2.9
	Rice	2.3	0.93
	Cassava	0.54	1.9
	Sweet potatoe	0.85	1.7
	Irish potatoe	2.1	0.17
	Yam	-	-
	Beans	6.7	14
	Peas	0.34	0.13
	Soy beans	0.18	0.005
	Other pulses	2.6	0.4
	Simsim	0.16	0.6
	Nuts	0.62	2.4
	Tomatoes	0.25	0.025
	Cabbages	-	-
	Onions	0.06	0.15
	Other vegetables	1.2	0.84
	Bananas	0.75	2.7
	Mangoes	-	-
	Fruits	0.52	-
	Coffee	0.01	0.05
	Pepper	-	0.01
	Sugarcane	0.25	0.04
Meat	Cattle	3.8	2.1
	Poultry	0.18	0.57
	Goat and sheep	0.73	0.51
	Pigs	0.065	0.96
Milk	Cow and goat	7.8	3.2
Eggs	Chicken	0.53	0.28
Others	Fish	1.2	3.7
	Honey	-	-

Table A.24: Determination of human excrement distribution in % from official data as used in the MFA. All values rounded to two significant digits.

	Bungoma			Busia		
	GoK & KNBS (2015)	GoK (2013a)	Mean	GoK & KNBS (2015)	GoK (2013b)	Mean
Open defecation	5.4	3	4.2	1.7	7.9	4.8
Pit latrines	91.1	90.7	90.9	95.6	86.4	91
Improved facilities[1]	2.5	5.9	4.2	2.7	5.5	4.1
Others[2]	1	0.4	0.7	-	0.1	0.1

Table A.24 continued

	Busia (UG)			Manafwa			Tororo		
	UBOS & ICF (2018)	UBOS (2017)	Mean	UBOS & ICF (2018)	UBOS (2017)	Mean	UBOS & ICF (2018)	UBOS (2017)	Mean
Open defecation	5.2	9.1	7.1	2.4	7.9	5.1	4.7	9.3	7
Pit latrines	94.4	90.9	92.4	96.7	92.1	93.9	94.7	90.8	92.5
Improved facilities[1]	0.5	-	0.5	1	-	1	0.6	-	0.6
Others[2]	-	-	-	-	-	-	-	-	-

[1] Sewers, sceptic tanks, improved pit latrines

[2] assumed as UDDT or similar

Table A.25: Coefficients a, b and c for the nutrient response functions from Wortmann & Keith (2017) as used in the analysis of yield increases

Coefficient	N	P	K
a	3.711	3.910	3.878
b	1.823	0.203	0.209
c	0.960	0.840	0.934

Table A.26: Values chosen from literature for plant availability of different nutrient sources in % as used for the nutrient response rate

Waste / product	N	P	K	Source
Manure	50	80	100	Shah et al. (2012)
Market waste	50	100	100	Kratz et al. (2019)
Organic MSW waste	50	100	100	Kratz et al. (2019)
Crop residues	50	100	100	Kratz et al. (2019)
Vermicompost	70	80	100	Duboc et al. (2017)
Composted faeces	70	100	100	Jönsson et al. (2004)
Stabilized urine	100	100	100	Jönsson et al. (2004)

Appendix B. Results from the material flow analysis

Table B.1: Summary of calculation results from the STAN model for Bungoma. All values rounded to two significant digits.

		N		P		K	
Flow	Name	Value	Unc.	Value	Unc.	Value	Unc.
F1.1	plant products	6300	1100	930	210	3300	730
F1.2	fodder crop residues & grazing	13000	1800	2100	330	31000	4400
F1.ex1	erosion	16000	5300	2900	2300	14000	7500
F1.ex2	crop residues to agricultural land & non-agricultural purposes	1600	420	360	89	3700	910
F1.i1	fodder from fallow & pasture	11000	1800	1700	340	27000	4500
F1.i2	total crop residues	5100	1400	1200	290	12000	3000
F1.i3	crop residues as fodder	1700	470	400	98	4100	1000
F1.i4	crop residues as mulch	1900	500	430	110	4300	1100
F1.im1	mineral fertilizer	5900	160	1500	750	520	93
F1.im2	N-fixation	1200	230	0	0	0	0
F2.1	animal products	520	130	58	14	80	24
F2.2	manure to agricultural land	6400	1600	1500	320	17000	3900
F2.3	vermi-compost	0	0	0	0	0	0
F2.ex1	manure losses (not collected)	2700	760	200	54	9100	2400
F2.ex2	manure losses to hydrosphere/ atmosphere	2600	690	240	64	2200	590
F2i1	excretion	12000	1700	1900	320	28000	4300
F2i2	manure losses	2600	690	240	64	2200	590
F2i3	manure to processing	0	0	0	0	0	0
F2i4	manure losses vermi-composting	0	0	0	0	0	0
F2i5	worms as chicken feed	0	0	0	0	0	0
F3.1	plant based food	4400	500	710	100	3000	360
F3.2	animal based food	1000	230	130	36	200	57
F3.3	market waste	35	13	7.1	4.1	66	20
F3.ex1	export plant products	3800	1100	540	210	1600	750
F3.ex2	export animal products	22	160	1.6	7.9	1.6	18
F3.im1	import plant products	2000	430	320	68	1300	440
F3.im2	import animal products	300	220	56	36	92	57
F3.im3	fish products (local/imported)	230	90	19	6.9	26	10
F4.1	organic MSW to cropland	410	120	82	38	700	180
F4.2	organic MSW as fodder	95	35	19	11	170	53
F4.3	human excrements to disposal or sanitation	4100	510	670	110	2000	330
F4.ex1	organic MSW to other land or waste management	150	55	30	17	270	82
F4.i1	organic household waste	660	130	130	40	1100	190
F5.1	treated faeces to agriculture	1.7	0.4	1.1	0.36	3	0.85
F5.2	treated urine to agriculture	23	2.9	3.6	0.65	11	2
F5.ex1	human excrement losses to other land/ atmosphere/ hydrosphere	4000	510	670	110	2000	330
F5.i1	human excrement from open defecation	170	45	28	8	85	24
F5.i2	human excrement to pit latrines	3700	470	610	98	1800	300
F5.i3	human excrement to sewer or sceptic tanks	170	46	28	8	85	24
F5.i4	urine and feaces to UDDTs	28	3.6	4.7	0.75	14	2.3
F5.i5	urine collected in jerry cans	0	0	0	0	0	0
F5.i6	human faeces losses from UDDTs	1.7	0.22	0	0	0	0
F5.i7	urine from UDDTs to distribution	25	3.2	3.6	0.65	11	2
F5.i8	urine losses from UDDTs and collection	2.5	0.32	0	0	0	0

Table B.2: Summary of calculation results from the STAN model for Busia (KE). All values rounded to two significant digits.

		N		P		K	
Flow	Name	Value	Unc.	Value	Unc.	Value	Unc.
F1.1	plant products	2000	470	310	84	1100	260
F1.2	fodder crop residues & grazing	7200	1200	1300	230	16000	3000
F1.ex1	erosion	4800	1500	830	660	4100	2200
F1.ex2	crop residues to agricultural land & non-agricultural purposes	460	170	87	33	900	370
F1.i1	fodder from fallow & pasture	6700	1300	1200	230	15000	3000
F1.i2	total crop residues	1500	550	290	110	3000	1200
F1.i3	crop residues as fodder	510	180	96	36	1000	410
F1.i4	crop residues as mulch	540	200	100	39	1100	430
F1.im1	mineral fertilizer	1500	40	380	200	140	24
F1.im2	N-fixation	630	88	0	0	0	0
F2.1	animal products	300	73	31	6.6	42	12
F2.2	manure to agricultural land	3600	1100	900	220	8800	2700
F2.3	vermi-compost	0	0	0	0	0	0
F2.ex1	manure losses (not collected)	1500	530	130	37	4800	1700
F2.ex2	manure losses to hydrosphere/ atmosphere	1500	480	150	44	1200	410
F2i1	excretion	6500	1200	1200	220	15000	3000
F2i2	manure losses	1500	480	150	44	1200	410
F2i3	manure to processing	0	0	0	0	0	0
F2i4	manure losses vermi-composting	0	0	0	0	0	0
F2i5	worms as chicken feed	0	0	0	0	0	0
F3.1	plant based food	2100	270	330	50	1500	170
F3.2	animal based food	860	290	110	34	170	54
F3.3	market waste	14	5.2	2.8	1.6	26	7.8
F3.ex1	export plant products	900	480	130	86	320	270
F3.ex2	export animal products	23	13	2	0.8	2.1	1.4
F3.im1	import plant products	990	210	150	32	700	170
F3.im2	import animal products	370	220	61	32	100	50
F3.im3	fish products (local/imported)	220	310	20	29	33	43
F4.1	organic MSW to cropland	230	67	45	21	380	98
F4.2	organic MSW as fodder	54	20	11	6.1	97	30
F4.3	human excrements to disposal or sanitation	2300	310	360	56	1000	170
F4.ex1	organic MSW to other land or waste management	60	22	12	6.8	110	33
F4.i1	organic household waste	340	70	68	21	580	100
F5.1	treated faeces to agriculture	0.14	0.033	0.087	0.027	0.21	0.06
F5.2	treated urine to agriculture	1.8	0.25	0.27	0.049	0.79	0.14
F5.ex1	human excrement losses to other land/ atmosphere/ hydrosphere	2300	310	360	56	1000	170
F5.i1	human excrement from open defecation	110	61	17	9.7	48	27
F5.i2	human excrement to pit latrines	2000	290	330	52	910	150
F5.i3	human excrement to sewer or sceptic tanks	92	33	15	5.4	41	15
F5.i4	urine and feaces to UDDTs	2.3	0.31	0.36	0.056	1	0.17
F5.i5	urine collected in jerry cans	0	0	0	0	0	0
F5.i6	human faeces losses from UDDTs	0.14	0.019	0	0	0	0
F5.i7	urine from UDDTs to distribution	2	0.28	0.27	0.049	0.79	0.14
F5.i8	urine losses from UDDTs and collection	0.2	0.028	0	0	0	0

Table B.3: Summary of calculation results from the STAN model for Busia (UG). All values rounded to two significant digits.

		N		P		K	
Flow	Name	Value	Unc.	Value	Unc.	Value	Unc.
F1.1	plant products	1200	370	180	61	630	180
F1.2	fodder crop residues & grazing	1500	120	300	28	3300	280
F1.ex1	erosion	590	310	100	92	500	340
F1.ex2	crop residues to agricultural land & non-agricultural purposes	260	140	52	27	510	310
F1.i1	fodder from fallow & pasture	1200	200	240	41	2700	450
F1.i2	total crop residues	870	470	170	89	1700	1000
F1.i3	crop residues as fodder	290	160	57	30	560	350
F1.i4	crop residues as mulch	310	170	61	32	600	370
F1.im1	mineral fertilizer	110	46	13	3.4	19	3.2
F1.im2	N-fixation	410	64	0	0	0	0
F2.1	animal products	58	8.9	5.2	0.5	6.1	1.2
F2.2	manure to agricultural land	740	100	210	27	1800	250
F2.3	vermi-compost	0	0	0	0	0	0
F2.ex1	manure losses (not collected)	300	48	33	5.6	980	160
F2.ex2	manure losses to hydrosphere/ atmosphere	310	45	34	5.2	240	36
F2i1	excretion	1300	110	270	28	3000	270
F2i2	manure losses	310	45	34	5.2	240	36
F2i3	manure to processing	0	0	0	0	0	0
F2i4	manure losses vermi-composting	0	0	0	0	0	0
F2i5	worms as chicken feed	0	0	0	0	0	0
F3.1	plant based food	930	160	150	21	730	100
F3.2	animal based food	220	54	19	4.4	26	6.6
F3.3	market waste	8.1	3	1.6	0.9	15	4.5
F3.ex1	export plant products	720	370	99	61	260	180
F3.ex2	export animal products	3.3	13	0.3	0.8	0.3	1.4
F3.im1	import plant products	480	250	63	27	380	140
F3.im2	import animal products	8.2	15	1.5	2	2.4	3.4
F3.im3	fish products (local/imported)	160	54	13	4.3	18	6.5
F4.1	organic MSW to cropland	87	26	17	7.9	160	39
F4.2	organic MSW as fodder	20	7.3	4	2.3	37	11
F4.3	human excrements to disposal or sanitation	840	150	130	21	470	100
F4.ex1	organic MSW to other land or waste management	35	13	6.9	3.9	64	19
F4.i1	organic household waste	140	28	28	8.5	260	41
F5.1	treated faeces to agriculture	0	0	0	0	0	0
F5.2	treated urine to agriculture	0	0	0	0	0	0
F5.ex1	human excrement losses to other land/ atmosphere/ hydrosphere	840	150	130	21	470	100
F5.i1	human excrement from open defecation	60	16	9.3	2.4	34	9.9
F5.i2	human excrement to pit latrines	780	140	120	19	440	94
F5.i3	human excrement to sewer or sceptic tanks	4.2	4.2	0.65	0.65	2.4	2.4
F5.i4	urine and feaces to UDDTs	0	0	0	0	0	0
F5.i5	urine collected in jerry cans	0	0	0	0	0	0
F5.i6	human faeces losses from UDDTs	0	0	0	0	0	0
F5.i7	urine from UDDTs to distribution	0	0	0	0	0	0
F5.i8	urine losses from UDDTs and collection	0	0	0	0	0	0

Table B.4: Summary of calculation results from the STAN model for Manafwa. All values rounded to two significant digits.

		N		P		K	
Flow	Name	Value	Unc.	Value	Unc.	Value	Unc.
F1.1	plant products	940	270	140	41	750	170
F1.2	fodder crop residues & grazing	2600	340	480	76	5800	800
F1.ex1	erosion	4300	1800	750	630	3700	2200
F1.ex2	crop residues to agricultural land & non-agricultural purposes	210	67	40	12	560	170
F1.i1	fodder from fallow & pasture	2300	350	430	77	5200	820
F1.i2	total crop residues	680	220	130	41	1900	550
F1.i3	crop residues as fodder	230	74	44	14	620	190
F1.i4	crop residues as mulch	250	79	47	15	670	200
F1.im1	mineral fertilizer	80	34	9.9	2.5	14	2.4
F1.im2	N-fixation	270	15	0	0	0	0
F2.1	animal products	100	19	11	2.3	14	3.8
F2.2	manure to agricultural land	1300	300	330	73	3100	720
F2.3	vermi-compost	0	0	0	0	0	0
F2.ex1	manure losses (not collected)	530	140	50	15	1700	440
F2.ex2	manure losses to hydrosphere/ atmosphere	520	130	53	14	420	110
F2i1	excretion	2300	330	430	74	5300	790
F2i2	manure losses	520	130	53	14	420	110
F2i3	manure to processing	0	0	0	0	0	0
F2i4	manure losses vermi-composting	0	0	0	0	0	0
F2i5	worms as chicken feed	0	0	0	0	0	0
F3.1	plant based food	1200	220	180	32	820	110
F3.2	animal based food	250	29	24	3.5	33	5.7
F3.3	market waste	7.6	2.8	1.5	0.9	14	4.2
F3.ex1	export plant products	240	210	32	39	260	160
F3.ex2	export animal products	9.9	20	0.9	1.1	0.79	2.3
F3.im1	import plant products	530	340	82	48	350	180
F3.im2	import animal products	39	27	4.4	3.5	5.9	5.9
F3.im3	fish products (local/imported)	120	19	9.5	1.1	14	2.4
F4.1	organic MSW to cropland	96	29	19	8.9	170	43
F4.2	organic MSW as fodder	23	8.2	4.5	2.6	41	12
F4.3	human excrements to disposal or sanitation	1100	210	170	31	560	100
F4.ex1	organic MSW to other land or waste management	32	12	6.5	3.6	59	18
F4.i1	organic household waste	150	30	30	9.4	270	45
F5.1	treated faeces to agriculture	0	0	0	0	0	0
F5.2	treated urine to agriculture	0	0	0	0	0	0
F5.ex1	human excrement losses to other land/ atmosphere/ hydrosphere	1100	210	170	31	560	100
F5.i1	human excrement from open defecation	57	25	8.7	3.8	28	12
F5.i2	human excrement to pit latrines	1100	200	160	29	520	96
F5.i3	human excrement to sewer or sceptic tanks	11	11	1.7	1.7	5.6	5.5
F5.i4	urine and feaces to UDDTs	0	0	0	0	0	0
F5.i5	urine collected in jerry cans	0	0	0	0	0	0
F5.i6	human faeces losses from UDDTs	0	0	0	0	0	0
F5.i7	urine from UDDTs to distribution	0	0	0	0	0	0
F5.i8	urine losses from UDDTs and collection	0	0	0	0	0	0

Table B.5: Summary of calculation results from the STAN model for Tororo. All values rounded to two significant digits.

		N		P		K	
Flow	Name	Value	Unc.	Value	Unc.	Value	Unc.
F1.1	plant products	2100	400	310	65	1000	220
F1.2	fodder crop residues & grazing	3400	680	640	150	7800	1600
F1.ex1	erosion	750	580	130	140	650	570
F1.ex2	crop residues to agricultural land & non-agricultural purposes	490	110	96	24	910	270
F1.i1	fodder from fallow & pasture	2900	690	540	150	6800	1600
F1.i2	total crop residues	1600	380	320	78	3000	890
F1.i3	crop residues as fodder	540	130	110	26	1000	300
F1.i4	crop residues as mulch	570	140	110	28	1100	320
F1.im1	mineral fertilizer	170	72	21	5.3	30	5
F1.im2	N-fixation	660	53	0	0	0	0
F2.1	animal products	160	28	16	2.3	20	4.4
F2.2	manure to agricultural land	1700	600	450	140	4200	1500
F2.3	vermi-compost	0	0	0	0	0	0
F2.ex1	manure losses (not collected)	690	290	68	29	2300	890
F2.ex2	manure losses to hydrosphere/ atmosphere	690	270	72	28	550	220
F2i1	excretion	3100	670	590	150	7100	1600
F2i2	manure losses	690	270	72	28	550	220
F2i3	manure to processing	0	0	0	0	0	0
F2i4	manure losses vermi-composting	0	0	0	0	0	0
F2i5	worms as chicken feed	0	0	0	0	0	0
F3.1	plant based food	1900	320	270	47	1200	160
F3.2	animal based food	360	41	35	4.9	48	8.2
F3.3	market waste	11	4	2.2	1.2	20	6
F3.ex1	export plant products	970	430	140	69	310	240
F3.ex2	export animal products	10	33	0.8	1.7	0.97	4.1
F3.im1	import plant products	740	490	96	67	510	240
F3.im2	import animal products	32	33	5.9	4.9	9.7	8.1
F3.im3	fish products (local/imported)	180	27	14	1.6	20	3.4
F4.1	organic MSW to cropland	140	42	28	13	250	63
F4.2	organic MSW as fodder	33	12	6.7	3.8	61	18
F4.3	human excrements to disposal or sanitation	1700	300	250	46	810	150
F4.ex1	organic MSW to other land or waste management	46	17	9.2	5.2	84	25
F4.i1	organic household waste	220	44	44	14	400	66
F5.1	treated faeces to agriculture	0	0	0	0	0	0
F5.2	treated urine to agriculture	0	0	0	0	0	0
F5.ex1	human excrement losses to other land/ atmosphere/ hydrosphere	1700	300	250	46	810	150
F5.i1	human excrement from open defecation	120	36	17	5.2	57	17
F5.i2	human excrement to pit latrines	1600	280	230	42	750	140
F5.i3	human excrement to sewer or sceptic tanks	10	10	1.5	1.5	4.9	4.9
F5.i4	urine and feaces to UDDTs	0	0	0	0	0	0
F5.i5	urine collected in jerry cans	0	0	0	0	0	0
F5.i6	human faeces losses from UDDTs	0	0	0	0	0	0
F5.i7	urine from UDDTs to distribution	0	0	0	0	0	0
F5.i8	urine losses from UDDTs and collection	0	0	0	0	0	0

Table B.6: Harvest response to nutrient application for the status quo S.0 and scenarios S.1 and S.2

	N			P			K		
Scenario	S.0	S.1	S.2	S.0	S.1	S.2	S.0	S.1	S.2
Bungoma	3.3	3.6 (8.3 %)	3.5 (7.5 %)	3.9	3.9 (0.57 %)	3.9 (0.58 %)	3.9	3.9 (0.6 %)	3.9 (0.6 %)
Busia (KE)	2.9	3.4 (20 %)	3.4 (18 %)	3.8	3.9 (1.3 %)	3.9 (1.3 %)	3.8	3.9 (1.3 %)	3.9 (1.3 %)
Busia (UG)	2.3	3.1 (33 %)	3 (29 %)	3.8	3.8 (1.9 %)	3.8 (2 %)	3.8	3.9 (1.3 %)	3.9 (1.3 %)
Manafwa	2.5	3.5 (42 %)	3.4 (39 %)	3.8	3.9 (2.3 %)	3.9 (2.3 %)	3.8	3.9 (0.83 %)	3.9 (0.83 %)
Tororo	2.4	3.3 (40 %)	3.2 (36 %)	3.8	3.9 (2.2 %)	3.9 (2.3 %)	3.8	3.9 (1.2 %)	3.9 (1.2 %)

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