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Model documentation

DairyWise

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Contents

1 Inputs

1.1 Livestock and feed management

Ncow	:	Number of cows	
Nheif	:	Number of animals between 1 and 2 years old	
Ncalf	:	Number of animals between 0 and 1 years old	
Graz	:	Grazing system (Table 1)	
Flc	:	Concentrate intake	kg DM cow^{-1} d^{-1}
Flr	:	Forage supplementation during grazing	kg DM cow^{-1} d^{-1}

Table 1 Graz

Code	Grazing system
O	Unrestricted grazing, day and night
B	Restricted grazing
Z	Zero grazing
S	Summer feeding

1.2 Land and crop management

Agras	:	Grassland area	ha
Amaize	:	Maize area	ha
Ngrass_level	:	Nitrogen application on grassland, relative to agronomic recommendations	%
Nmaize_level	:	Nitrogen application on maize, relative to agronomic recommendations	%
Reseeding		Proportion of grassland renewal	%
Soil	:	Soil type (Table 2)	
SNS	:	Soil nitrogen supply (Table 3)	kg N ha^{-1}
GT	:	Ground water level (Table 4)	

Table 2 Soil

Code	Soil types
Sand_thick	Sandy soil with a thick humorous layer (> 30 cm)
Sand_thin	Sandy soil with a thin humorous layer (< 30 cm)
Loam_clay	Loam with a clay sub layer
Loam	Loam with sand or peat sub layer
Loess	Loess
Clay_heavy	Clay with a heavy clay sub layer
Clay	Clay or clay with a peat or sand sub layer
Peat	Peat
Peat_clay	Peat with a clay sub layer
Peat_sand	Peat with a sand sub layer

Table 3 SNS

SNS	Soil nitrogen supply (kg ha^{-1})
SNS50	50
SNS60	60
SNS70	70
…	…
SNS300	300

Table 4 GT

Groundwater levels	Average highest groundwater level (cm under field level)	Average lowest groundwater level (cm under field level)
II	0 - 40	50 - 80
II*	25 - 40	50 - 80
III	0 - 40	80 - 120
III*	25 - 40	80 - 120
IV	> 40	80 - 120
V	0 - 40	> 120
V*	25 - 40	> 120
VI	40 - 80	> 120
VII	> 80	> 160

1.3 Miscellaneous

PRICEmlk	:	Milk price	€ kg^{-1}
Quotum	:	Milk quotum	kg
Contractor	:	Proportion of field work done by contractors	%

2 Crops

2.1 Grassland

2.1.1 Dry matter yield

DMYgrass	=	DMYpot / Drought	
DMYgrass	:	Actual grass yield	1000 kg DM ha^{-1}
DMYpot	:	Potential grass yield without water limitation	1000 kg DM ha^{-1}
DroughtGrass	:	Yield reduction due to water limitation (Table 5)	%

Table 5 Drought grass

Ground water level	Sand_ thick	Sand_ thin	Loam_ clay	Loam	Loess	Clay_ heavy	Clay	Peat	Peat_ clay	Peat_ sand
II	-3	-1	-3	-1	-3	0	-2	-1	-1	-1
II*	-2	-2	-3	0	-3	1	-2	0	1	0
III	-2	2	-2	4	-3	7	0	4	4	4
III*	-2	2	2	4	-3	9	0	5	5	4
IV	1	4	-2	4	-4	9	1	4	4	4
V	2	8	1	8	-2	16	4	12	11	11
V*	5	10	2	11	-2	17	7	14	14	14
VI	11	16	5	12	-3	22	12	21	20	20
VII	17	21	10	15	-3	26	17	29	29	29

DMYpot	=	a * aMaxGrowth / (Limit * (1 + exp(Limit *(T_MaxGrowth- GRD)))) - b	
DMYpot	:	Potential grass yield without water limitation	1000 kg DM ha^{-1}
MaxGrowth_i	:	Maximum daily growth in first (i=1) or later (i=r) growth cycles	1000 kg DM ha^{-1} d^{-1}
T_MaxGrowth_i	:	Day number of maximum daily growth in first (i=1) or later (i=r) growth cycles	d
Limit_i	:	Parameter defining the upper yield limit in first (i=1) or later (i=r) growth cycles	d^{-1}
GRD	:	Day number from start growing cycle	d
a	=	4	
b	=	0.4	
T_MaxGrowth_1	=	80	
T_MaxGrowth_r	=	30	

MaxGrowth_1	=	a * DMY_Nfactor + b * $(DMY\_Nfactor)^2$ + c	
MaxGrowth_1	:	Maximum daily growth in first growth cycle	1000 kg DM ha^{-1} d^{-1}
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
a	:	0.0445	
b	:	-0.0044	
c	:	0.0837	

MaxGrowth_r	=	(c + a * Tstart + b * $(Tstart)^2$ + d * (DMY_Nfactor) + e * $(DMY\_Nfactor)^2$ + f * Tstart * (DMY_Nfactor)	
MaxGrowth_r	:	Maximum daily growth in later growth cycles	1000 kg DM ha^{-1} d^{-1}
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
Tstart	:	Starting day of a growing cycle	d
a	:	-0.0446	
b	:	0.0000536	
c	:	9.86	
d	:	1.608	
e	:	-0.1792	
f	:	-0.00322	

DMY_Nfactor	=	(SNSgrcycle – SNS170grcycle) / a)+ Nappl + Nres_DM) / b + c	
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
SNSgrcycle	:	Soil nitrogen supply during growth cycle (Table 6)	kg N ha^{-1}
SNS170grcycle		Soil nitrogen supply from a standard soil during growth cycle	kg N ha^{-1}
Napp	:	Nitrogen application	kg N ha^{-1}
Nres_DM	:	Residual effect of previous N application on DM yield (Table 7)	kg N ha^{-1}
a	:	0.8	
b	:	40	
c	:	1	

Table 6 SNSgrcycle

	SNS						
day	50	100	150	170	200	250	300
60-90	0.04	0.14	0.23	0.27	0.33	0.43	0.53
91-120	0.08	0.27	0.47	0.54	0.66	0.86	1.05
121-150	0.12	0.41	0.70	0.82	0.99	1.28	1.58
151-200	0.30	0.60	0.90	1.02	1.20	1.50	1.80
201-250	0.20	0.40	0.60	0.68	0.80	1.00	1.20
>250	0.15	0.30	0.45	0.51	0.60	0.75	0.90

Table 7 Nres_DM

	Day					
Previous N application	<140	141-165	166-190	191-220	221-244	245-280
0	-15.8	-27.3	-32.7	-33.1	-32.5	-35.
40	30.1	-0.5	-9.5	-7.6	-10	-4.4
80	35.8	12.8	2.3	0.6	0	-1.6
120	31.5	20.6	7.3	1.9	-7.5	-18.6

Limit_1	=	a * DMY_Nfactor + b * $(DMY\_Nfactor)^2$ + c	
Limit_1	:	Parameter defining the upper yield limit in first growth cycle	d^{-1}
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
	:		
a	:	-0.00811	
b	:	0.00080	
c	:	0.1017	

Limit_r	=	a * DMY_Nfactor + c	
Limit_r	:	Parameter defining the upper yield limit in later growth cycles	d^{-1}
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
	:		
a	:	0.00699	
c	:	0.09684	

2.1.2 Nitrogen yield

NYgrass_i	=	NCgrass_i + NCdil * ln(DMYgrass)	
NYgrass_i	:	Nitrogen yield of grass in the first (i=1) or later (i=r) growth cycles	Kg N ha^{-1}
NCgrass_i	:	Nitrogen content in grass in the first (i=1) or later (i=r) growth cycles	Kg N 1000 kg DM^{-1}
NCdil	:	Parameter that describes dilution of nitrogen over time	
DMYgrass	:	Actual grass yield	1000 kg DM ha^{-1}

NCgrass_1	=	a + b * NY_Nfactor	
NCgrass_1	:	Nitrogen content in grass in the first growth cycle	Kg N 1000 kg DM^{-1}
NY_Nfactor	:	Nitrogen supply factor for N yield	Kg N ha^{-1}
a	=	22.49	
b	=	2.941	

NCgrass_r	=	A * NY_Nfactor + b * $(NY\_Nfactor)^2$ + c	
NCgrass_r	:	Nitrogen content in grass in the remaining growth cycles	Kg N 1000 kg DM^{-1}
NY_Nfactor	:	Nitrogen supply factor for N yield	Kg N ha^{-1}
a	=	14.58	
b	=	-1.517	
c	=	Table 8	

Table 8 c

Day number	<105	105-135	136-165	166-195	196-225	226-255	> 255
c	21.35	15.61	10.1	19.1	16.29	18.65	17.42

NCdil	=	a * NY_Nfactor + b * $(NY\_Nfactor)^2$ + c	
NCdil	:	Parameter that describes dilution of nitrogen over time	
NY_Nfactor	:	Nitrogen supply factor for N yield	Kg N ha^{-1}
a	=	4.21	
b	=	0.733	
c	=	Table 9	

Table 9 c

Day number	<105	105-135	136-165	166-195	196-225	226-255	> 255
c	23.33	21.26	36.59	30.60	33.42	35.42	41.66

NY_Nfactor	=	(SNSgrcycle – SNS170grcycle) / a) + Nappl + b * Nres) / c + d	
NY_Nfactor	:	Nitrogen supply factor for N yield	Kg N ha^{-1}
SNSgrcycle	:	Soil nitrogen supply during growth cycle (Table 6)	Kg N ha^{-1}
SNS170grcycle	:	Soil nitrogen supply from a standard soil during growth cycle	Kg N ha^{-1}
Napp	:	Nitrogen application	Kg N ha^{-1}
Nres_N	:	Residual effect of previous N application on N yield (Table 10)	Kg N ha^{-1}
a	:	0.8	
b	:	0.5	
c	:	40	
d	:	1	

Table 10 Nres_N

Day number in year	140	165	190	220	244	280
Last fresh N supply						
0	-7	-18	-33	-50	-50	-50
40	-14	-2	-11	-17	-31	-35
80	23	13	4	3	0	0
120	27	25	23	28	31	39

2.1.3 Feeding value

VEM	=	a * ME + b / GE * $(ME)^2$	
VEM	:	Feed Unit Miilk	kg DM^{-1}
ME	:	Metabolizable energy	g kg DM^{-1}
GE	:	Gross energy	g kg DM^{-1}
a	=	0.27376521	
b	=	0.142	

DVE	=	DVBE + DVME - DVMFE	
DVE	:	Digestable true protein	g kg DM^{-1}
DVBE	:	Rumen undegraded protein, absorbed in the small intestine	g kg DM^{-1}
DVME	:	Digestible microbial rumen protein	g kg DM^{-1}
DVMFE	:	Endogenous protein losses in digestion	g kg DM^{-1}
DVMFE	=	100	

OEB	=	MREN - MREE	
OEB	:	Degraded protein balance	g kg DM^{-1}
MREN	:	Potential microbial protein synthesis based on available nitrogen	g kg DM^{-1}
MREE	:	Potential microbial protein synthesis based on available energy	g kg DM^{-1}

ME	=	a * (VOS/VRE <= 7)* VOS + b (VOS/VRE >7) * VOS + (VOS/VRE <= 7) *c * VRE	
ME	:	Metabolizable energy	g kg DM^{-1}
VOS	:	Digestable organic matter	g kg DM^{-1}
VRE	:	Digestable crude protein	g kg DM^{-1}
a	=	3.4	
b	=	3.6	
c	=	1.4	

GE	=	c + a * RE + b*RC + d * (1000 – RAS – RC – RE – e)	
GE	:	Gross energy	g kg DM^{-1}
RC	:	Crude fibre	g kg DM^{-1}
RE	:	Crude protein	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
a	=	5.77	
b	=	5	
c	=	349.6	
d	=	4.06	
e	=	40	

VRE	=	a * RE + b * RAS + c	
VRE	:	Digestable crude protein	g kg DM^{-1}
RE	:	Crude protein	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
a	=	0.959	
b	=	0.04	
c	=	-40	

VOS	=	A * RC + b * RAS + c + (d *(day + e))	
VOS	:	Digestable organic matter	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
day	:	Day number	
a	=	-0.77	
b	=	-1.12	
c	=	1029	
d	=	-0.3	
e	=	-90	

PCBRE	=	c + a * RE + b * Minimum((Day + d),e)	
PCBRE	:	Proportion of undegraded protein	%
Day	:	Day number of the harvest day	
RE	:	Crude protein	g kg DM^{-1}
a	=	-0.09	
b	=	0.04	
c	=	48.7	
d	=	90	
e	=	180	

PCDVBE	=	c * (PCBRE + a (b + d * Minimum((Day + e),f))/RE/ PCBRE	
PCDVBE	:	Intestinally digestable BRE	%
PCBRE	:	Proportion of undegraded protein	%
Day	:	Day number of the harvest day	
RE	:	Crude protein	g kg DM^{-1}
a	=	-100	
b	=	12	
c	=	100	
d	=	0.07	
e	=	90	
f	=	180	

DVBE	=	a * RE * (PCBRE/c) * (PCDVBE/100)	
DVBE	:	Rumen undegraded protein, absorbed in the small intestine	g kg DM^{-1}
PCBRE	:	Proportion of undegraded protein	%
PCDVBE	:	Proportion of Intestinally digestable BRE	%
RE	:	Crude protein	g kg DM^{-1}
a	:	1.11	

FOS	=	VOS – (RE * PCBRE / c) + a	
FOS	:	Fermentable organic matter	g kg DM^{-1}
PCBRE	:	Proportion of undegraded protein	%
VOS	:	Digestable organic matter	g kg DM^{-1}
RE	:	Crude protein	g kg DM^{-1}
a	:	-40	
c	:	100	

DVME	=	a * FOS	
DVME	:	Digestible microbial rumen protein	g kg DM^{-1}
FOS	:	Fermentable organic matter	g kg DM^{-1}
a	=	0.095625	

DVMFE	=	a *(1000 – VOS – Minimum(RAS/b,c))	
DVMFE	:	Endogenous protein losses in digestion	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
VOS	:	Digestable organic matter	g kg DM^{-1}
a	=	0.075	
b	=	2	
c	=	60	

MREN	=	RE * (a + b * PCBRE/c)	
MREN	:	Potential microbial protein synthesis based on available nitrogen	g kg DM^{-1}
PCBRE	:	Proportion of undegraded protein	%
RE	:	Crude protein	
A	=	1	
B	=	-1.11	
c	=	100	

MREE	=	a * FOS	
MREE	:	Potential microbial protein synthesis based on available energy	g kg DM^{-1}
FOS	:	Fermentable organic matter	g kg DM^{-1}
a	=	0.15	

Crude_fibre_1	=	(c + a * DMYgrass_1 + b * SQR(DMYgrass_1) + d* ((Napp + ((SNSgrcycle-SNS170grcycle)/e))/f+1))*1000	
Crude fibre_1	:	Crude fibre content in the first cut	g kg DM^{-1}
DMYgrass_1	:	Dry matter yield in the first cut	kg DM ha^{-1}
SNSgrcycle	:	Soil nitrogen supply during growth cycle (Table 6)	kg N ha^{-1}
SNS170grcycle	:	Soil nitrogen supply from a standard soil during growth cycle	kg N ha^{-1}
Napp	:	Nitrogen application	kg N ha^{-1}
a	=	0.02564	
b	=	-0.000653	
c	=	0.15671	
d	=	-0.007236	
e	=	0.8	
f	=	40	

Crude_fibre_r	=	(c1 +c2 * DMYgrass_r + b * $(DMYgrass\_r)^2$ + d* ((N_app + ((SNSgrcycle-SNS170grcycle)/e))/f+1))/ DMYgrass_r	
Crude fibre_r	:	Crude fibre content in later cuts	g kg DM^{-1}
DMYgrass_r	:	Dry matter yield in later cuts	kg DM ha^{-1}
SNSgrcycle	:	Soil nitrogen supply during growth cycle (Table 6)	kg N ha^{-1}
SNS170grcycle	:	Soil nitrogen supply from a standard soil during growth cycle	kg N ha^{-1}
Napp	:	Nitrogen application	kg N ha^{-1}
b	=	14.339	
c1,c2	=	Table 11	
d	=	-10.292	
e	=	0.8	
f	=	40	

Table 11 c1,c2

	Day number					
	135-165	166-195	196-225	226-255	256-285	> 285
c1	-7.6	-10.2	8.3	30	25	31.2
c2	199.56	215.34	201.5	172.93	164.5	175.52

RAS_1	=	(c + a * DMYgrass_1 + b *(Nappl/ d + 1)	
RAS_1	:	Crude ash content in the first cut	g kg DM^{-1}
DMYgrass_1	:	Dry matter yield in the first cut	kg DM ha^{-1}
Napp	:	Nitrogen application	kg N ha^{-1}
a	=	-0.149	
b	=	3.358	
c	=	71.2	
d	=	40	

RAS_r	=	(C + a * DMYgrass_r + b * SQR(DMYgrass_r) + d * DMY_Nfactor	
RAS_r	:	Crude ash content in later cuts	g kg DM^{-1}
DMYgrass_r	:	Dry matter yield in later cuts	kg DM ha^{-1}
Napp	:	Nitrogen application	kg N ha^{-1}
DMY_Nfactor	:	Nitrogen supply factor for DM yield	kg N ha^{-1}
a	=	84.42	
b	=	-2.627	
c	=	-10.29	
d	=	10.496	

RE	=	(Nuptake / DMYield) * a	
RE	:	Crude protein	g kg DM^{-1}
DMYgrass	:	Dry matter grass yield	Kg DM ha^{-1}
NYgrass	:	Nitrogen yield of grass	Kg N ha^{-1}
a	:	6.25	

2.2 Forage Maize

2.2.1 Nitrogen yield

NYmaize	=	a + b * Nsup + c * Nsup * Nsup / 100	Kg N ha^{-1}
NYmaize	:	Nitrogen yield maize	Kg N ha^{-1}
Nsup	:	Nitrogen supply factor	Kg N ha^{-1}
a	=	61.26	
b	=	0.1749	
c	=	-0.03812	

Nsup	=	Nmanure + Nfert + Nmin + Ngr + Ncc + Npast	
Nsup	:	Nitrogen supply factor	Kg N ha^{-1}
Nmin	:	Nitrogen supply from soil	Kg N ha^{-1}
Napp	:	Nitrogen application	Kg N ha^{-1}
Npl	:	Nitrogen supply from ploughed grassland (Table 12)	Kg N ha^{-1}
Ncc	:	Nitrogen supply from a catch crop (Table 14)	Kg N ha^{-1}
Nres	:	Nitrogen supply from previous applications (Table 16)	Kg N ha^{-1}
Nmin	=	20	Kg N ha^{-1}

Table 12 Npl

Age of grassland at time of ploughing grassland (year)	Present age of maize land (year)	Npl (kg year^{-1})
1	1	50 * Plough time factor (Table 13)
2 or more	1	100 * Plough time factor (Table 13)
3 or more	2	30

Table 13 Plough time factor

Ploughing time grassland	Plough time factor
Autumn	0.70
February	0.75
March	1.00
April	0.80
April (after harvest of grass)	0.60
May (after harvest of grass)	0.00

Table 14 Ncc

Use of catch crop	Ncc (kg year^{-1})
Harvested	0
Under ploughed	40 * plough time factor (Table 15)

Table 15 Plough time factor

Ploughing time catch crop	Plough time factor
Before 1st of April	0.32
After 1st of April	0.70

Table 16 Nres

Fertilization of nitrogen in the past	Nitrogen supply (kg ha^{-1})
Low (<= 20 ton manure ha^{-1} year^{-1})	-25
High (> 20 ton manure ha^{-1} year^{-1})	0

2.2.2 Dry matter yield

DMYmaize	=	DMYpot * (100 – DroughtMaize) /100 * NitrogenMaize * WeedMaize * RotationMaize * SowMaize	
DMYmaize	:	Actual maize yield	kg DM ha^{-1}
DroughtMaize	:	Damage by drought (Table 17)	%
WeedMaize	:	Factor of weed removal (Table 18)	kg kg^{-1}
RotationMaize	:	Factor of crop rotation"(Table 19)	kg kg^{-1}
SowMaize	:	Factor of sowing (Table 20)	kg kg^{-1}
NitrogenMaize	:	Factor of nitrogen on yield	kg kg^{-1}
DMYpot	:	Current potential maize yield without water and nitrogen limitations	
DMYpot	=	17113	kg DM ha^{-1}

Table 17 Drought Maize

	Sand_ thick	Sand_ thin	Loam_ clay	Loam	Loess	Clay_ heavy	Clay	Peat	Peat_ clay	Peat_ sand
II	0	2	0	1	0	2	0	-	0	1
II*	1	1	0	2	0	3	0	-	1	2
III	1	5	1	6	0	9	2	-	5	6
III*	1	5	1	7	0	11	2	-	7	7
IV	1	6	1	7	0	11	2	-	7	7
V	4	11	3	11	0	18	5	-	14	14
V*	5	14	4	12	0	20	7	-	16	17
VI	8	19	6	14	0	23	11	-	23	24
VII	14	24	11	17	1	26	18	-	31	32

Table 18 Weed Maize

Weed removal method	
Mechanical	0.975
Use of herbicides	1.000

Table 19 Rotation Maize

Age of grassland at time of ploughing grassland (year)	
No grassland before ploughing	1.00
1	1.00
2	1.03
3	1.05
4 or more	1.07

Table 20 Sow Maize

Manner of weed removal	Yield factor
Traditional sowing	1.0
Direct sowing	0.7

Nitrogen Maize	=	DMYnitrogen / DMYexp	
Nitrogen Maize	:	Factor of nitrogen on yield	kg kg^{-1}
DMYnitrogen	:	Standard dry matter yield of maize at the corresponding nitrogen supply	kg DM ha^{-1}
DMYexp	:	Average DM yield of maize experiments	
DMYexp	=	14850	kg DM ha^{-1}

DMYnitrogen	=	a + b * Nupt + c * $(Nupt)^2$ * 10	
YIELDSTm	:	Standard dry matter yield of maize at a certain nitrogen level	kg DM ha^{-1}
Nupt	:	Uptake of nitrogen by the plant	kg
a	=	-4.82	
b	=	1.1038	
c	=	- 0.192	

2.2.3 Feeding value

DVEsm	=	a + b * Nsup	
Nsm	:	Nitrogen in silage of maize	g kg dm^{-1}
Nsup	:	Nitrogen supply	kg ha^{-1}
a	=	43.297	
b	=	0.0222	

OEBsm	=	a + b * Nsup	
Nsm	:	Nitrogen in silage of maize	g kg dm^{-1}
Nsup	:	Nitrogen supply	kg ha^{-1}
a	=	-40.98	
b	=	0.06544	

3 Animals

3.1 Cow model

3.1.1 Feed intake

Flgr	=	(FlCAP – Flc*SVc – Flr*SVr) / SVgr	
Flgr	:	Feed intake of grass at grazing	kg DM d^{-1}
FlCAP	:	Feed intake capacity of cows in lactation	SV d^{-1}
Flc	:	Feed intake of concentrate	kg DM d^{-1}
Flr	:	Feed intake of roughage besides grass at pasture	kg DM d^{-1}
SVc	:	Saturation value of concentrate	SV kg DM^{-1}
SVr	:	Saturation value of roughage besides grass	SV kg DM^{-1}

Flr	=	(FlCAP – Flc*SVc) / SVr	
Flr	:	Feed intake of roughage indoor	kg DM d^{-1}
FlCAP	:	Feed intake capacity of cows in lactation	SV d^{-1}
Flc	:	Feed intake of concentrate	kg DM d^{-1}
SVc	:	Saturation value of concentrate	SV kg DM^{-1}

FlCAP	=	(a0 + a1*(1 - Exp(-ra*PAR))) *Exp(b*(1 - Exp(-rb*DL))) *(1 + d*(DG/220));	
FlCAP	:	Feed intake capacity of cows in lactation	SV d^{-1}
PAR	:	Parity	
DL	:	Days of lactation	days
DG	:	Days of gestation	days
a0	=	8.0838	
a1	=	3.2956	
Ra	=	1.2758	
b	=	0.3983	
Rb	=	0.05341	
d	=	0.06907	

3.1.2 Saturation values

SVc	=	Exp (c0 + c31*(RC-140)/1000)	
SVc	:	Saturation value of concentrate	SV kg DM^{-1}
RC	:	Crude fibre	g kg DM^{-1}
c0	=	-1.1483	
c31	=	1.335	

SVgr	=	Exp (c0 + c31*(RC-230)/1000 + c32*Sqr(RC-230/1000 + c51*(VOS-705)/1000)	
SVgr	:	Saturation value of grass	SV kg DM^{-1}
RC	:	Crude fibre	g kg DM^{-1}
VOS	:	Digestible organic matter	g kg DM^{-1}
c0	=	-0.08334	
c31	=	-0.206	
c32	=	0.01419	
c51	=	-0.7443	

SVsg	=	Exp (c11*(DS-45)/1000 + c12*Sqr(DS-45)/1000 + c21*(RE-170)/1000 + c31*(RC-240)/1000)	
SVsg	:	Saturation value of silage of grass	SV kg DM^{-1}
DS	:	Dry matter	%
RE	:	Crude protein	g kg DM^{-1}
RC		Crude fibre	g kg DM^{-1}
			g kg DM^{-1}
c11	=	-1.613	
c12	=	0.0991	
c21	=	-0.3321	
c31	=	1.551	

SVsm	=	Exp (c0 + c11*(DS-33)/1000 + c12*Sqr(DS-33)/1000 + c51*(VOS-695)/1000)	
SVsm	:	Saturation value of silage of maize	SV kg DM^{-1}
DS	:	Dry matter	%
VOS	:	Digestible organic matter	g kg DM^{-1}
c0	=	-0.21658	
c11	=	-2.737	
c12	=	2.962	
c51	=	-0.559	

SVr	=	(FIsm*SVsm + FIsg* SVsg) / (FIsm + FIsg)	
SVr	:	Saturation value of roughages	SV kg DM^{-1}
FIsm	:	Feed intake of silage of maize	kg DM d^{-1}
FIsg	:	Feed intake of silage of grass	kg DM d^{-1}
SVsm	:	Saturation value of silage of maize	SV kg DM^{-1}
SVsg	:	Saturation value of silage of grass	SV kg DM^{-1}

3.1.3 Energy requirement

ENEtot	=	ENEbasic + ENEmob + ENEmlk	
ENEtot	:	Energy requirement total	VEM
ENEbasic	:	Basic energy	VEM
ENEmob	:	Energy for mobilization	VEM
ENEmlk	:	Energy for milk	VEM

ENEbasic	=	a0 + a1 * (1 - Exp(-ra*PAR))	
ENEbasic	:	Basic energy requirement	VEM
PAR	:	Parity	
a0	=	7020	
a1	=	1116.5	
Ra	=	1.099	

ENEmob	=	ENEbasic * (a3 - a4*PAR) * Exp (-ra*DL)	
ENEmob	:	Energy mobilized	VEM
ENEbasic	:	Basic energy	VEM
PAR	:	Parity	
DL	:	Days of lactation	days
a3	=	0.8070	
a4	=	-0.05497	
Ra	=	0.024481	

ENEmlk	=	b * MMLK	
ENEmlk	:	Energy requirement milk production	VEM
MLK	:	Standardized production of milk	kg
b	=	434.18	

3.1.4 Protein requirement

PROTtot	=	PROTmnt + PROTgr + PROTmlk + PROTgst + PROTmob	
PROTtot	:	Protein requirement total	G DVE
PROTmnt	:	Protein requirement maintenance	g DVE
PROTgr	:	Protein requirement growth	g DVE
PROTmlk	:	Protein requirement milk production	g DVE
PROTgst	:	Protein requirement gestation	g DVE
PROTmob	:	Protein requirement mobilization	g DVE

PROTmnt	=	(a * Power(WEIGHT,0.5) + b * Power(WEIGHT,0.6)) / c	
PROTmnt	:	Protein requirement maintenance	g DVE
WEIGHT	:	Weight	kg
a	=	2.75	
b	=	0.2	
c	=	0.67	

PROTgr	=	37 * (P=1) + 19 * (P=2)	
PROTgr	:	Protein requirement growth	g DVE
P		Number of parity	

PROTmlk	=	(MLKreal * MLKprot * 10) / (100/(a+b*(MLKreal*MLKprot*10)))	
PROTmlk	:	Protein requirement milk production	g DVE
MLKreal	:	Milk production realized	kg
MLKprot	:	Protein in milk	%
a	=	1.396	
b	=	0.000195	

PROTgst	=	a*Exp(b-c*EXP(-d*DG) - d*DG) / e	
PROTgst	:	Protein requirement gestation	g DVE
DG	:	Days of gestation	d
a	=	34.375	
b	=	8.5357	
c	=	13.1201	
d	=	0.00262	
e	=	0.5	

PROTmob	=	(ENEintake - ENEtot)/1000 * a *(ENEintake > ENEtot) +(ENEintake - ENEtot)/1000 * b *(ENEintake < ENEtot)	
PROTmob	:	Protein requirement mobilization	g DVE
ENEintake	:	Intake of energy	VEM
ENEtot	:	Total requirement of energy	VEM
a1	=	57	
a2	=	45	

3.1.5 Weight

WEIGHT	=	(a0+a1*(1-Exp(-ra*PAR)))*Exp((b*(1-Exp(-rb*DL))) /(1+Exp(rg*(Ln(DL)-g))))	
WEIGHT	:	Weight	kg
PAR	:	Parity	
DL	:	Days of lactation	d
a0	=	594.35	
a1	=	137.57	
ra	=	0.3118	
b	=	-0.10314	
rb	=	0.1206	
rg	=	9.00	
g	=	5.3279	

3.1.6 Realized milk production

MLKreal	=	(1 + (1-Exp(a*(1-FACene) - b*Sqr(1-FACene))) * MMLK	
MLKreal	:	Milk production realized	kg
FACene	:	Factor for surplus of energy	
MMLK	:	Standardized milk production	kg
a	=	1.07695	
b	=	1.292	

FACene	=	ENEintake / ENEtot	
FACene	:	Factor for surplus of energy	
ENEintake	:	Intake of energy	VEM
ENEtot	:	Total requirement of energy	VEM

ENEintake	=	CONCint * CONCVEM + GRint * GRVEM + SGint * SGVEM + SMint * SMVEM	
ENEintake	:	Total intake of energy	VEM
CONCint	:	Intake of concentrate	kg DM
GRint	:	Intake of grass	kg DM
SGint	:	Intake of silage of grass	kg DM
SMint	:	Intake of silage of maize	kg DM
CONCVEM	:	Energy value of concentrate	VEM kg DM^{-1}
GRVEM	:	Energy value of grass	VEM kg DM^{-1}
SGVEM	:	Energy value of silage of grass	VEM kg DM^{-1}
SMVEM	:	Energy value of silage of maize	VEM kg DM^{-1}

3.1.7 Production of standard cow

MMLK	=	a1*MLK+a2*MLKfat+a3*MLKprot	
MMLK	:	Standardized milk production	kg
MLK	:	Standard production of milk	kg
MLKfat	:	Fat in milk	%
MLKprot	:	Protein in milk	%
a1	=	0.337	
a2	=	0.116	
a3	=	0.060	

MLK	=	(a0+(a1-a2*DL)*(1-Exp(-ra*PAR)))*0.1 * Exp((b*(1-Exp(-rb*DL))) / (1+Exp(rg*(Ln(DL)-g))))	
MLK	:	Milk production	kg
PAR	:	Parity	
DL	:	Days of lactation	d
a0	=	142.23	
a1	=	100.77	
a2	=	0.3912	
ra	=	1.0267	
b	=	0.494	
rb	=	0.10262	
rg	=	1.957	
g	=	5.6304	

MLKfat	=	(a0+a1*(1-Exp(-ra*PAR)))*Exp((b*(1-Exp(-rb*DL))) /(1+Exp(rg*(Ln(DL)-g))))	
MLKfat	:	Fat in milk	%
PAR	:	Parity	
DL	:	Days of lactation	d
a0	=	533.01	
a1	=	27.98	
ra	=	1.153	
b	=	-0.28574	
Rb	=	0.06502	
Rg	=	3.345	
G	=	5.6315	

MLKprot	=	(a0+a1*(1-Exp(-ra*PAR)))*Exp((b*(1-Exp(-rb*DL))) /(1+Exp(rg*(Ln(DL)-g))))	
MLKprot	:	Protein in milk	%
PAR	:	Parity	
DL	:	Days of lactation	d
a0	=	471.92	
a1	=	13.6	
Ra	=	2.21	
B	=	-0.44212	
Rb	=	0.10239	
Rg	=	1.5358	
G	=	5.6632	

3.2 Young stock model

3.2.1 Feed intake

FImax	=	(a + b * Power(WEIGHT,c) -((d - FEEDVEM)/100.0) * (e + f * WEIGHT)) - FIc * CONCpush	
FImax	:	Maximal intake of roughage	kg DM
WEIGHT	:	Weight of animal (Table 22)	kg
FEEDVEM	:	VEM in roughage	VEM kg DM^{-1}
FIc	:	Concentrate intake	kg DM
CONCsub	:	Substitution factor of concentrate and roughage	kg DM kg DM^{-1}
a	=	-2.14774	
b	=	0.57851	
c	=	0.46574	
d	=	850.0	
e	=	0.3727	
f	=	0.000991	

Flr	=	(ENEtot – Flmlk * MLKVEM – Flc * CONCVEM) / FEEDVEM	
Flr	:	Feedintake of roughage	kg DM
ENEtot	:	Energy requirement total	VEM
Flmlk	:	Milk intake	kg
Flc	:	Concentrate intake	kg DM
MLKVEM	:	VEM in milk	VEM kg^{-1}
CONCVEM	:	VEM in concentrate	VEM kg DM^{-1}
FEEDVEM	:	VEM in roughage	VEM kg DM^{-1}

CONCsub	=	a*Flc - b*WEIGHT + c*FEEDVEM + d	
CONCsub	:	Substitution factor of concentrate and roughage	kg DM kg DM^{-1}
WEIGHT	:	Weight of animal (Table 22)	kg
FEEDVEM	:	VEM in roughage	VEM kg DM^{-1}
Flc	:	Concentrate intake	kg DM
a	=	0.0219	
b	=	0.000785	
c	=	0.000608	
d	=	0.148	

3.2.2 Energy requirement

ENEtot	=	ENEmnt+ENEgr+ENEgst+ENEgrz	
ENEtot	:	Energy requirement total	VEM
ENEmnt	:	Energy for maintenance	VEM
ENEgr	:	Energy for growth	VEM
ENEgst	:	Energy for gestation	VEM
ENEgrz	:	Energy for grazing	VEM

ENEmnt	=	a * Power(WEIGHT,0.75) * KJTOVEM + Wfetus * b	
ENEmnt	:	Energy for maintenance	VEM
WEIGHT	:	Weight animal (Table 22)	kg
Wfoetus	:	Weight foetus	kg
KJTOVEM	:	Conversion factor from KJ to VEM	
a	=	330	
b	=	6.0	

Wfetus		(-a + a * Exp(b*DG)) * c	
Wfetus	:	Weight foetus (incl. fluid)	kg
DG	:	Days of gestation	d
a	=	-0.6087	
b	=	0.0174	
c	=	0.9	

KJTOVEM	=	(f1 * UFmlk/UFmgr) * f2/f3	
KJTOVEM	:	Conversion factor from KJ to VEM	
UFmlk	:	Utilization factor for milk	
UFmgr	:	Utilization factor maintenance and growth	
f1	=	0.9752	
f2	=	1.15	
f3	=	6.90	

UFmlk	=	a + b * QVALUE
UFmlk	:	Utilization factor for milk
QVALUE	:	Q value (Table 21)
a	=	0.4632
b	=	0.0024

Table 21 QVALUE

Age (d)	QVALUE
1 - 69	0.70
70 - 182	0.60
183 - 730 (grazing)	0.60
183 - 730 (non grazing)	0.55

UFmgr	=	UFgr / (((UFgr - UFmnt) /(UFmnt * APL)) + 1)
UFmgr	:	Utilization factor maintenance and growth
UFgr	:	Utilization factor for growth
UFmnt	:	Utilization factor for maintenance
APL	:	Animal Production Level

UFmnt	=	a + b * QVALUE
UFmnt	:	Utilization factor for maintenance
a	=	0.554
b	=	0.00287

UFgr	=	a + b * QVALUE
UFgr	:	Utilization factor for growth
a	=	0.006
b	=	0.0078

APL	=	1.0 + ENEgr / ENEmnt	
APL	:	Animal Production Level	
ENEmnt	:	Energy for maintenance	VEM
ENEgr	:	Energy for growth	VEM

ENEgr	=	(((a + b*GROWTH) * c * GROWTH) / (1.0 - GROWTH*d)) *KJTOVEM	
ENEgr	:	Energy for growth	VEM
GROWTH	:	Growth of animal (Table 22)	kg d^{-1}
KJTOVEM	:	Conversion factor from KJ to VEM	
a	=	500	
b	=	6.0	
c	=	4.184	
d	=	0.3	

ENEgst	=	a * Exp(b * DG) * c	
ENEgst	:	Energy for gestation	VEM
DG	:	Days of gestation	d
a	=	17.5	
b	=	0.0174	
c	=	0.9	

ENEgrz	=	a + b * WEIGHT	
ENEgrz	:	Energy for grazing	VEM
WEIGHT	:	Weight of animal (Table 22)	kg
a	=	150	
b	=	1.67	

Table 22 Growth

Age (d)	Growth (g/day)
1 - 61	575
62 - 242	825
243 - 365	700
366 - 456	700
457 - 670	625
671 - 730	(730 – age) / 60.0 * 625

3.2.3 Protein requirement

PROTtot	=	PROTmnt + PROTgr + PROTgst	
PROTtot	:	Protein requirement total	g DVE
PROTmnt	:	Protein requirement maintenance	g DVE
PROTgr	:	Protein requirement growth	g DVE
PROTgst	:	Protein requirement gestation	g DVE

PROTmnt	=	(a * Power(WEIGHT,0.5) + b * Power(WEIGHT,0.6)) / c	
PROTmnt	:	Protein requirement maintenance	g DVE
WEIGHT	:	Weight of animal (Table 22)	kg
a	=	2.75	
b	=	0.2	
c	=	0.67	

WEIGHTf	=	a * Exp(b + c * Ln(LLG) + d * Power(Ln(LLG),e))	
WEIGHTf	:	Weight of fat	kg
LLG	:	Empty body weight	kg
a	=	1.5	
b	=	-1.680	
c	=	0.0189	
d	=	0.1609	
e	=	2	

LLG	=	Exp(a + b * Ln(WEIGHT)	
LLG	:	Empty body weight	kg
WEIGHT	:	Weight of animal (Table 22)	kg
a	=	-0.2855	
b	=	1.023	

PROTgr	=	1000.0 * GROWTHp / Max(a - b*WEIGHT, c)	
PROTgr	:	Protein requirement growth	g DVE
GROWTHp	:	Growth of protein	kg
WEIGHT	:	Weight of animal (Table 22)	kg
a	=	0.8	
b	=	0.0009	
c	=	0.4	

GROWTHf	=	(WEIGHTf / LLG * (a + 2 * b * Ln(LLG)) * c) / d * Power(GRLLG, e)	
GROWTHf	:	Growth of fat	kg
WEIGHTf	:	Weight of fat	kg
LLG	:	Empty body weight	kg
GRLLG	:	Growth empty body weight	kg
a	=	0.0189	
b	=	0.1609	
c	=	0.76	
d	=	0.613548	
e	=	1.78	

GRLLG	=	(LLG / WEIGHT) * a *GROWTH	
GRLLG	:	Growth empty body weight	kg
LLG	:	Empty body weight	kg
WEIGHT	:	Weight of animal (Table 22)	kg
GROWTH	:	Growth of animal (Table 22)	kg d^{-1}
a	=	1.023	

GROWTHp	=	a * b * (GRLLG - GROWTHf) *Power(LLG – WEIGHTf, c)	
GROWTHp	:	Growth of protein	kg
GROWTHf	:	Growth of fat	kg
GRLLG	:	Growth empty body weight	kg
LLG	:	Empty body weight	kg
a	=	1.060	
b	=	0.1541	
c	=	0.06	

PROTgst	=	(a*Exp(b-c*EXP(-d*DG) - d*DG) / e) * f	
PROTgst	:	Protein requirement gestation	g DVE
DG	:	Days of gestation	d
a	=	34.375	
b	=	8.5357	
c	=	13.1201	
d	=	0.00262	
e	=	0.5	
f	=	0.9	

3.3 Herd model

3.3.1 Herd composition

Table 23 Distribution of calvings per month for different patterns

Pattern	Spring (%)	Fall (%)	Spreaded (%)
January	15	10	10
February	20	5	10
March	25	5	15
April	15	0	10
May	5	0	5
June	0	0	5
July	0	0	5
August	0	5	5
September	0	15	5
October	5	25	10
November	5	20	10
December	10	15	10
Total	100	100	100

Table 24 Distribution of parities in herd at different replacement levels of the herd (%)

	20% replacement	25% replacement	30% replacement	35% replacement	40% replacement
Parity = 1	20.0	25.0	30.0	35.0	40
Parity = 2	17.5	20.0	22.1	23.6	24.6
Parity = 3	15.6	16.4	16.7	16.4	15.7
Parity = 4	13.5	13.0	12.1	10.9	9.5
Parity = 5	11.2	9.9	8.4	6.9	5.5
Parity = 6+	22.2	15.7	10.7	7.2	4.7
Total	100	100	100	100	100

3.3.2 Culling

Table 25 Partition of involuntary and voluntary culling

	Involuntary culling (%)	Voluntary culling (%)
Calves	100	0
Heifers	25	75
Cows, parity = 1	70	30
Cows, parity = 2	85	15
Cows, parity = 3	87.5	12.5
Cows, parity = 4	85	15
Cows, parity = 5	80	20
Cows, parity = 6+	60	40

Table 26 Period of culling within a year

	Period (days in year)	Partition of total involuntary culling (%)
Calves	1 - 60	60
	61 - 365	40
Heifers	1 - 210	27
	211 - 308	67
	309 - 365	6
Cows	1 - 28	15
	29 - 154	28
	155 - 308	51
	309 - 365	6

Table 27 Period of culling within a year

	Period (days in year)	Partition of total voluntary culling (%)
Calves	365	100
Heifers	154	100
Cows	203	100

3.3.3 Required number of young stock

Nccow	=	Ncow * (a + REPL/100 * b))	
Nccow	:	Number of calving cows	
Ncow	:	Number of average present cows	
REPL	:	Replacement level of the herd	%
a	=	0.96993	
b	=	0.7258	

Nreqcalf	=	((REPL * Nccow)/100) / ((1 - (VCc + ICc)/100) * (1 - (VCh + ICh)/100))	
Nreqcalf	:	Number of required calves for replacement	
Nccow	:	Number of calving cows	
REPL	:	Replacement level of the herd	%
VCc	:	Voluntary culling of calves	%
ICc	:	Involuntary culling of calves	%
VCh	:	Voluntary culling of heifers	%
ICh	:	Involuntary culling of heifers	%

Nreqheif	=	Nreqcalf *(1 - (VCc + ICc)/100)	
Nreqheif	:	Number of required heifers for replacement	
VCc	:	Voluntary culling of calves	%
ICc	:	Involuntary culling of calves	%

4 Feed Supply

4.1 Net feed supply

4.1.1 Field losses

Table 28 Grazing losses

Grazing system	Losses (%)
Zero grazing	7
Restricted grazing	16
Day-and-night grazing	22

Table 29 harvest losses

Grazing system	Losses (%) per activity
Tedding	1.2
Loading	2.0

4.1.2 Conservation losses

VOS_cons.	=	a * RC + b * RAS + c + d * DMper * 10	
VOS	:	Digestable organic matter of conserved grass silage	g kg DM^{-1}
RC	:	Crude fibre	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
DMper	:	Dry matter fraction of silage (Table 30)	%
a	:	-0.77	
b	:	-1.23	
c	:	1027	
d		-0.03	

VRE_cons	=	a * RE + b * RAS + c + (d + e * NH_3 fraction)	
VRE_cons	:	Digestable crude protein of conserved grass silage	g kg DM^{-1}
RE	:	Crude protein	g kg DM^{-1}
RAS	:	Crude ash	g kg DM^{-1}
NH_3 fraction	:	Ammonia fraction (Table 30)	g kg DM^{-1}
a	=	0.895	
b	=	0.04	
c	=	-40	
d	=	8	
e	=	-0.7	

PCBRE_cons	=	c + a * RE + b * Min((Day + 90),180) + d * DMper	
PCBRE_cons	:	Proportion of undegraded protein in conserved silage	%
RE	:	Crude protein	g kg DM^{-1}
DMper	:	Dry matter fraction of silage (Table 30)	%
Day	:	Day number of the harvest day	
a	=	-0.09	
b	=	0.04	
c	=	29.5	
d	=	0.3	

FOS_cons	=	VOS – (RE * PCBRE_cons / 100) + b * (c * DMper + d * NH_3 fraction + e) + a	
FOS_cons	:	Fermentable organic matter of conserved silage	g kg DM^{-1}
PCBRE_cons	:	Proportion of undegraded protein in conserved silage	%
VOS	:	Digestable organic matter	g kg DM^{-1}
RE	:	Crude protein	g kg DM^{-1}
DMper	:	Dry matter fraction of silage (Table 30)	%
NH_3 fraction	:	Ammonia fraction (Table 30)	g kg DM^{-1}
a	=	-40	
b	=	-0.5	
c	=	-3	
d	=	2	
e	=	170	

Table 30 NH3fraction and DMper

Cutting method	Wilting period (d)	Harvest method	NH3fraction	DMper
Disk mower	2	Pick-Up	11	25
Disk mower	3	Pick-Up	12	25
Disk mower	4	Pick-Up	13	25
Disk mower	2	Chopped	9	25
Disk mower	3	Chopped	10	25
Disk mower	4	Chopped	11	25
Disk mower	2	Pick-Up	9	40
Disk mower	3	Pick-Up	10	40
Disk mower	4	Pick-Up	11	40
Disk mower	2	Chopped	9	40
Disk mower	3	Chopped	10	40
Disk mower	4	Chopped	11	40
Disk mower	2	Pick-Up	9	45
Disk mower	3	Pick-Up	10	45
Disk mower	4	Pick-Up	11	45
Disk mower	2	Chopped	9	45
Disk mower	3	Chopped	10	45
Disk mower	4	Chopped	11	45
Conditioner	1	Pick-Up	8	25
Conditioner	2	Pick-Up	10	25
Conditioner	1	Chopped	8	25
Conditioner	2	Chopped	9	25
Conditioner	1	Pick-Up	8	40
Conditioner	2	Pick-Up	9	40
Conditioner	1	Chopped	8	40
Conditioner	2	Chopped	9	40
Conditioner	1	Pick-Up	8	45
Conditioner	2	Pick-Up	9	45
Conditioner	1	Chopped	8	45
Conditioner	2	Chopped	9	45

4.1.3 Feeding losses

Table 31 feeding losses

Feed	Losses (%)
Roughage	5
Concentrate	2

4.2 Grassland management

Paddock_value	=	Mark_DMY * 25 + Mark_grazdays * 25 + Mark_ aftermath * 25 + Mark_ growth time * 10
Paddock_value	:	Total marks for paddock choice
Mark_DMY	:	Marks for DM yield of grass (Table 32)
Mark_grazdays	:	Marks for available grazing days (Table 33)
Mark_aftermath	:	Marks for previous paddock use (Table 34)
Mark_Growthtime	:	Marks for number of growing days (Table 35)

Table 32 Mark_DMY

DM Yield (kg ha^{-1})	Mark
< 6 00	18
600 - 1700	18 – DM yield/100
1700 - 3000	DMYield/100 – 16
> 3000	14

Table 33 Mark_grazdays

Number of grazing days	Mark
< 4.5	1
4.5	2
> 4.5 - 5	3
> 5 – 5.5	4
> 5.5 – 6	6
> 6	10

Table 34 Mark_aftermath

Previous use	Mark
Mowing	0
Grazing	8

Table 35 Mark_growthtime

Growing time (days)	Mark
< 28	1
28 – 35	3
> 35	10

5 Nutrient cycling

5.1 Fertilizing standards

5.1.1 Nitrogen on grassland

Ngrass	=	Ngrass_rec * Ngrass_level / 100	
Ngrass_rec	:	Advice of nitrogen from manure and fertilizer for grassland	kg N ha^{-1}
Ngrass_level	:	Nitrogen application on grassland, relative to agronomic recommendations	%

Ngrass_rec	=	a - b * SNS	
Ngrass_rec	:	Advice of nitrogen from manure and fertilizer for grassland	kg N ha^{-1}
SNS	:	Soil nitrogen supply	kg N ha^{-1} $year^{-1}$
a	=	Table 36	
b	=	Table 36	

Table 36 a,b

Time of fertilization	Expected yield at use (kg DM ha^{-1})	a	b
First cut	< 1000	93.794	0.18893
	1000-1500	118.621	0.21915
	1500-2000	138.887	0.24265
	2000-2500	156.211	0.26736
	2500-3000	167.844	0.27911
	> 3000	175.322	0.28821
Second cut	< 1000	18.425	0.03050
	1000-1500	31.025	0.06872
	1500-2000	62.187	0.10381
	2000-2500	90	0.1346
	2500-3000	117.066	0.17495
	> 3000	138.921	0.20187
May / June	< 1000	15.687	0.03140
	1000-1500	38.953	0.05490
	1500-2000	60.432	0.08225
	2000-2500	79.047	0.10862
	2500-3000	95.468	0.13476
	> 3000	109.863	0.16449
July	< 1000	10.714	0.02138
	1000-1500	29.02	0.03746
	1500-2000	43.491	0.04725
	2000-2500	54.955	0.05982
	2500-3000	64.809	0.08068
	> 3000	71.861	0.09654
August	< 1000	9.249	0.01832
	1000-1500	25.077	0.03214
	1500-2000	37.553	0.04485
	2000-2500	46.089	0.05845
	2500-3000	53.933	0.07842
	> 3000	-	-
September	< 1000	9.022	0.018639
	1000-1500	32.693	0.038639
	1500-2000	34.663	0.058779
	2000-2500	44.818	0.081649
	2500-3000	-	-
	> 3000	-	-

5.1.2 Nitrogen on maize

Nmaize	=	N,maize_rec * Nmaize_level / 100	
Nmaize_rec	:	Advice of nitrogen from manure and fertilizer for maize	kg N ha^{-1}
Nmaize_level	:	Nitrogen application on maize, relative to agronomic recommendations	%

Nmaize_rec	=	a - Nmin - Ngr - Ncc – Npast	
Nmaize_rec	:	Advice of nitrogen from manure and fertilizer for maize land	Kg N ha^{-1}
Nmin	:	Nitrogen supply from soil	Kg N ha^{-1}
Npl	:	Nitrogen supply from ploughed grassland (Table 12)	Kg N ha^{-1}
Ncc	:	Nitrogen supply from a catch crop (Table 14)	Kg N ha^{-1}
Npast	:	Nitrogen supply from previous applications (Table 16)	Kg N ha^{-1}
a	=	180	
Nmin	=	20	Kg N ha^{-1}

5.1.3 Phosphate

Table 37 Advice of phosphate for grassland (kg P_2O_5 ha^{-1})

Phosphate status of soil	First cut All systems Once	Other cuts Day-and-night grazing Once	Other cuts Restricted grazing Once	Other cuts Mowing Every cut
Low	110	10	20	20
Quite low	70	10	20	20
Sufficient	45	10	20	20
Amply sufficient	25	10	20	20
High	15	0	0	0

Table 38 Advice of phosphate for maize land (kg P_2O_5 ha^{-1})

PW value of soil	In field only Applying in field	In row only Applying in row	Combination Applying in field	Combination Applying in row
10	185	92	125	30
15	170	85	110	30
20	150	75	90	30
25	135	67	75	30
30	120	60	60	30
35	105	52	55	30
40	85	42	25	30
45	70	35	10	30
50	55	27	0	30
55	35	17	0	20
60	0	0	0	0
65	0	0	0	0
70	0	0	0	0

5.1.4 Potassium

Table 39 Advice of potassium for grassland on sandy soils (kg K_2O ha^{-1})

Potassium status of soil	First cut Grazing Once	First cut Mowing Once	Other cuts Grazing Once	Other cuts Mowing Every cut
Low	100	180	90	100
Sufficient	60	140	90	100
Amply sufficient	0	80	90	80
High	0	40	0	60
Very high	0	0	0	0

Table 40 Advice of potassium for grassland on other soils (kg K_2O ha^{-1})

Potassium status of soil	First cut Grazing Once	First cut Mowing Once	Other cuts Grazing=B Once	Other cuts Mowing norm Every cut
Low	80	160	90	100
Sufficient	20	100	90	100
Amply sufficient	0	60	90	50
High	0	30	0	0
Very high	0	0	0	0

Table 41 Advice of potassium for maize land (kg K_2O ha^{-1})

K value of soil	Continual culture Sandy soils	Continual culture Other soils	Variable culture Sandy soils	Variable culture Other soils, Org matter <10%	Variable culture Other soils, Org matter >10%
4	300	300	320	160	330
6	300	300	280	160	330
8	300	300	250	130	290
10	300	300	220	100	250
12	260	300	180	70	210
14	210	300	160	50	170
16	160	240	140	30	140
18	110	190	120	0	120
20	60	140	110	0	100
22	30	90	100	0	80
24	0	40	80	0	70
26	0	0	70	0	50
28	0	0	60	0	40
30	0	0	50	0	0
32	0	0	40	0	0
34	0	0	30	0	0
36	0	0	0	0	0
38	0	0	0	0	0
40	0	0	0	0	0

5.2 Manure fertilizer equivalents

Table 42 Manure fertilizer equivalents of nitrogen on grassland

Method of application	Period of application	Fertilizer equivalent (%)
Shallow injection	Spring	50
	Summer	50
	Fall	25
Trailing feet	Spring	40
	Summer	40
	Fall	28

Table 43 Manure fertilizer equivalents of nitrogen on maize land

Application method	Fertilizer equivalent (%)
Surface application followed by ploughing	57
Injection	64
Row injection	80

Table 44 Manure fertilizer equivalents of phosphate and potassium

	Fertilizer equivalent (%)
Phosphate	100
Potassium	100

5.3 Animal excretion

5.3.1 Excretion of nitrogen

N_faeces	=	NIdiet * (1 – DCDIET_ prot)	
N_faeces	:	Excretion of nitrogen via faeces	kg
NIdiet	:	Nitrogen intake of diet	kg
DCDIET_prot	:	Digestion coefficient of protein in diet	%

N_urine	=	NIdiet * DCDIET_ prot – NABS_tot	
N_urine	:	Excretion of nitrogen via urine	kg
NIdiet	:	Nitrogen intake of diet	kg
DCDIET_prot	:	Digestion coefficient of protein in diet	%
NABS_tot	:	Absorption of nitrogen	kg

5.3.2 Excretion of phosphate

P_faeces	=	(PIdiet - PABS_tot) * (1 – a)	
P_faeces	:	Excretion of phosphate via faeces	kg
PIdiet	:	Phosphate intake of diet	kg
PABS_tot	:	Absorption of phosphate	kg
a	=	0.03	

P_urine	=	(PIdiet - PABS_tot) * a	
P_faeces	:	Excretion of phosphate via urine	kg
PIdiet	:	Phosphate intake of diet	kg
PABS_tot	:	Absorption of phosphate	kg
a	=	0.03	

5.3.3 Excretion of potassium

K_faeces	=	(KIdiet - KABS_tot) * (1 – a)	
K_faeces	:	Excretion of potassium via faeces	kg
KIdiet	:	Potassium intake of diet	kg
KABS_tot	:	Absorption of potassium	kg
a	=	0.8	

K_urine	=	(Kldiet - KABS_tot) * a	
K_faeces	:	Excretion of potassium via urine	kg
Kldiet	:	Potassium intake of diet	kg
KABS_tot	:	Absorption of potassium	kg
a	=	0.8	

5.3.4 Excretion of dry matter

DM_faeces	=	Dldiet * (1 – DCDIET_ dm)	
DM_faeces	:	Excretion of dry matter via faeces	kg
Dldiet	:	Dry matter intake of diet	kg
DCDIET_dm	:	Digestion coefficient of dry matter in diet	%

DM_urine	=	N_urine * a + K_urine * b	
DM_urine	:	Excretion of dry matter via urine	kg
N_urine	:	Excretion of nitrogen via urine	kg
K_urine	:	Excretion of potassium via urine	kg
a	=	2.144	
b	=	1.907	

5.3.5 Digestion

DCDIET_dm	=	(Dlconc * DCconc + Dlgr * DCgr + Dlsg * DCsg + Dlsm * DCsm) / (Dlconc + Dlgr + Dlsg + Dlsm)	
DCDIET_dm	:	Digestion coefficient of dry matter in diet	%
Dlconc	:	Dry matter intake of concentrate	kg dm
Dlgr	:	Dry matter intake of grass	kg dm
Dlsg	:	Dry matter intake of silage of grass	kg dm
Dlsm	:	Dry matter intake of silage of maize	kg dm
DCconc	:	Digestion coefficient of dry matter of concentrate (Table 45)	%
DCgr	:	Digestion coefficient of dry matter of grass (Table 45)	%
DCsg	:	Digestion coefficient of dry matter of silage of grass (Table 45)	%
DCsm	:	Digestion coefficient of dry matter of silage of maize (Table 45)	%

DCDIET_prot	=	(Nlconc * PCconc + Nlgr * PCgr + Nlsg * PCsg + Nlsm * PCsm) / (Nlconc + Nlgr + Nlsg + Nlsm) * (1 - DIGDEPR_prot)	
DCDIET_prot	:	Digestion coefficient of protein in diet	%
Nlconc	:	Nitrogen intake of concentrate	kg
Nlgr	:	Nitrogen intake of grass	kg
Nlsg	:	Nitrogen intake of silage of grass	kg
Nlsm	:	Nitrogen intake of silage of maize	kg
PCconc	:	Digestion coefficient of protein of concentrate (Table 45)	%
PCgr	:	Digestion coefficient of protein of grass (Table 45)	%
PCsg	:	Digestion coefficient of protein of silage of grass (Table 45)	%
PCsm	:	Digestion coefficient of protein of silage of maize (Table 45)	%

Table 45 Standard amount of minerals and digestion coefficients of feeds

Feed	Nitrogen (g N/kg)	Phosphorus (g P/kg)	Potassium (g K/kg)	DC dry matter (%)	DC protein (%)
Grass	31 – 41 *	4.3	36.6	0.70 – 0.80 *	0.75 – 0.82 *
Silage of grass	26 – 34 *	4.1	34.1	0.65 – 0.75 *	0.68 – 0.74 *
Silage of maize	13.2	1.9	13.4	0.70	0.55
Concentrate, 90 DVE	24.0	4.0	15.0	0.80	0.71
Concentrate, 120 DVE	32.0	5.0	16.0	0.80	0.77
Concentrate, 180 DVE	48.0	8.0	20.0	0.80	0.86

* related to nitrogen application (2.1.3)

5.3.6 Absorption

MINABS_tot	=	MINABS_milk + MINABS_meat + MINABS_foet	
MINABS_tot	:	Absorption of minerals (N,P,K) by the animal	kg
MINABS_milk	:	Absorption of minerals by the animal in milk	kg
MINABS_meat	:	Absorption of minerals by the animal in meat	kg
MINABS_foet	:	Absorption of minerals by the animal in foetus	kg

MINABS_milk	=	Ncow * MLKPROD * a	
MINABS_milk	:	Absorption of minerals (N,P,K) by the cows in milk	kg
Ncow	:	Number of cows	
MLKPROD	:	Production of milk	kg year^{-1}
a	=	Mineral in milk (Table 46)	g kg^{-1}

MINABS_meat	=	((Nccow*REPL/100 *	
		(GRp1+GRp2+GRp3+GRp4+GRp5+GRp6)	
		- Nculp1 * (0.5*GRp1+GRp2+GRp3+GRp4+GRp5+GRp6)	
		- Nculp2 * (0.5*GRp2+GRp3+GRp4+GRp5+GRp6)	
		- Nculp3 * (0.5*GRp3+GRp4+GRp5+GRp6)	
		- Nculp4 * (0.5*GRp4 + GRp5 + GRp6)	
		- Nculp5 * (0.5*GRp5 + GRp6)	
		- Nculp6 * (0.5*GRp6))	
		+ Nheifers * GRheifers + Ncalves * GRcalves) * a	
MINABS_meat	:	Absorption of minerals (N,P,K) by the cows in meat	kg
Nccow	:	Number of calving cows	
REPL	:	Replacement level of the herd	%
GRp1	:	Growth of cows in parity 1	kg year^{-1}
GRp2	:	Growth of cows in parity 2	kg year^{-1}
GRp3	:	Growth of cows in parity 3	kg year^{-1}
GRp4	:	Growth of cows in parity 4	kg year^{-1}
GRp5	:	Growth of cows in parity 5	kg year^{-1}
GRp6	:	Growth of cows in parity 6	kg year^{-1}
GRheifers	:	Growth of heifers	kg year^{-1}
GRcalves	:	Growth of calves	kg year^{-1}
Nculp1	:	Number of culled cows in parity 1	
Nculp2	:	Number of culled cows in parity 2	
Nculp3	:	Number of culled cows in parity 3	
Nculp4	:	Number of culled cows in parity 4	
Nculp5	:	Number of culled cows in parity 5	
Nculp6	:	Number of culled cows in parity 6	
Nheifers	:	Number of heifers	
Ncalves	:	Number of calves	
a	=	Minerals in meat (Table 46)	g kg^{-1}

MINABS_foet	=	Nccow * Wcalf * a/1000	
MINABS_foet	:	Absorption of minerals (N,P,K) by the cows in foetus	kg
Nccow	:	Number of calving cows	
Wcalf	:	Weight of calf at birth	kg
a	=	Minerals in foetus (Table 46)	g kg^{-1}

Table 46 Minerals in milk, meat and foetus

	Nitrogen (g N/kg)	Phosphorus (g P/kg)	Potassium (g K/kg)
Milk	MLKPROT / 6.38	0.9	1.5
Meat	25.3	7.4	1.7
Foetus	29.5	8.0	2.05

5.4 Manure in storage

EXCR_indoor	=	100 * (1 - TIMEGRAZ/24)	
EXCR_indoor	:	Percentage of excretion indoor	%
TIMEGRAZ	:	Time of grazing	hours d^{-1}

TIMEGRAZ	=	a - b * Sforage	
TIMEGRAZ	:	Time of grazing	hours d^{-1}
Sforage	:	Forage supplementation during grazing	kg DM cow^{-1} d^{-1}
a	=	(Table 47)	
b	=	(Table 47)	

Table 47 a,b

	a	b	Minimum	Maximum
Pasture, system O	24	-1.6	1	20
Pasture, system B	10	-0.5	1	20
Indoor	24	0	-	-

MANURE_Norg	=	EXCR_indoor/100 * (N_faeces + (N_urine * (1-a)) + N_spillfeed + N_str	
MANURE_Norg	:	Total organic nitrogen of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
N_faeces	:	Excretion of nitrogen via faeces	kg
N_urine	:	Excretion of nitrogen via urine	kg
N_spillfeed	:	Nitrogen from feeding losses	kg
N_str	:	Nitrogen from bedding material	kg
a	=	0.8	

MANURE_Nmin	=	EXCR_indoor/100 * (N_urine * a)	
MANURE_Nmin	:	Total mineral nitrogen of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
N_urine	:	Excretion of nitrogen via urine	kg
a	=	0.8	

MANURE_Pfc	=	EXCR_indoor/100 * (P_faeces + P_spillfeed + P_str)	
MANURE_Pfc	:	Total phosphate of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
P_faeces	:	Excretion of phosphate via faeces	kg
P_spillfeed	:	Phosphate from feeding losses	kg
P_str	:	Phosphate from bedding material	kg

MANURE_Pur	=	EXCR_indoor/100 * P_urine	
MANURE_Pur	:	Total organic phosphate of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
P_urine	:	Excretion of phosphate via urine	kg

MANURE_Kfc	=	EXCR_indoor/100 * (K_faeces + K_spillfeed + K_str)	
MANURE_Kfc	:	Total organic potassium of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
K_faeces	:	Excretion of potassium via faeces	kg
K_spillfeed	:	Potassium from feeding losses	kg
K_str	:	Potassium from bedding material	kg

MANURE_Kur	=	EXCR_indoor/100 * K_urine	
MANURE_Kur	:	Total potassium of manure in storage	kg
EXCR_indoor	:	Percentage of excretion indoor	%
K_urine	:	Excretion of potassium via urine	kg

5.5 Ammonia emission

5.5.1 Housing and storage

EMFLOOR	=	(Ncows + a*Nheifers + b*Ncalves) * c * EMBASIC / d	
EMFLOOR	:	Daily emission of ammonia from floor	kg
EMBASIC	:	Daily emission of ammonia from floor and internal storage	kg
Ncows	:	Number of cows indoor	
Nheifers	:	Number of heifers indoor	
Ncalves	:	Number of calves indoor	
a	=	0.58	
b	=	0.31	
c	=	0.6	
d	=	1.214	

EMSTORint	=	(Ncows + a*Nheifers + b*Ncalves) * c * EMBASIC / d	
EMSTORint	:	Daily emission of ammonia from internal storage	kg
EMBASIC	:	Daily emission of ammonia from floor and internal storage	kg
Ncows	:	Number of cows indoor	
Nheifers	:	Number of heifers indoor	
Ncalves	:	Number of calves indoor	
a	=	0.58	
b	=	0.31	
c	=	0.4	
d	=	1.214	

EMBASIC	=	Exp(a + b * (TEMPindoor – 15) + (d1/c) * FIMDVE + (d2/c) * FIMoeb - (d3/c) * FIMoeb * FIMoeb) / 190	
EMBASIC	:	Daily emission of ammonia from floor and storage	kg cow^{-1}
TEMPindoor	:	Indoor temperature	^0C
FIMDVE	:	Intake of DVE	kg cow^{-1}
FIMoeb	:	Intake of OEB	kg cow^{-1}
a	=	0.504	
b	=	0.02738	
c	=	0.2464	
d1	=	0.1558	
d2	=	0.3152	
d3	=	0.1169	

EMSTORext	=	(EMFACstor * (STORVext/STORHext)) * (1 - 0.01 * EMREDcover)	
EMSTORext	:	Daily emission of ammonia from external storage	kg
STORVext	:	Volume of external storage	m^3
EMFACstor	:	Emission factor external storage (Table 48)	kg m^{-2}
EMREDcover	:	Emission reduction by cover of external storage (Table 48)	%
STORH_ext	:	Height of external storage	m

Table 48 EMFACstor, EMREDcover

	Summer	Winter
Emission factor external storage	0.01248	0.00888
Reduction of emission in external storage with floating cover	84	80
Reduction of emission in external storage covered by a tent	84	71
Reduction of emission in external storage covered by a plate	32	46
Reduction of emission in external storage covered by concrete	84	75

5.5.2 Grazing

EMGRAZING	=	a * (N_faeces + N_urine) * (1 - EXCR_indoor/100)	
EMGRAZING	:	Emission of ammonia during grazing	kg
N_faeces	:	Excretion of nitrogen via faeces	kg
N_urine	:	Excretion of nitrogen via urine	kg
EXCR_indoor	:	Percentage of excretion indoor	%
a		0.08	

5.5.3 Manure application

EMAPPL	=	a/100 * (N_manure)	
EMAPPL	:	Emission of ammonia from manure application	kg
N_manure	:	Nitrogen in applied manure	kg
a		(Table 49)	

Table 49 a

Application method of slurry	Emission of ammonia (%)
Maize land, conventional and ploughing	2.5
Maize land, sod injection	1.0
Maize land, slurry in row	2.5
Grassland, sod application	10
Grassland, “sleepvoeten”	25

5.5.4 Fertilizer application

EMFERT	=	a/100 * (N_fertilizer)	
EMFERT	:	Emission of ammonia from fertilizer application	kg
N_manure	:	Nitrogen in applied fertilizer	kg
a		(Table 50)	

Table 50 a

Fertilizer	Emission of ammonia (%)
KAS	1.5
AS	10

5.6 Nitrate leaching

5.6.1 Grassland

NO3grass	=	62/14 * SMNgrass * DNF / PRECIPgrass * 10000	
NO3grass	:	Basic nitrate concentration in groundwater of grassland	mg l^{-1}
SMNgrass	:	Soil mineral nitrogen (0-100 cm)	kg ha^{-1}
DNF	:	Denitrification factor (Table 51)	
PRECIPgrass	:	Surplus of precipitation on grassland	mm

Table 51 DNF

Groundwater level type	Denitrification factor
II	0.05
II*	0.00
III	0.08
III*	0.32
IV	0.43
V	0.52
V*	0.48
VI	0.64
VII	0.84

SMNgrass	=	SMNbasic + SMNurine	
SMNgrass	:	Soil mineral nitrogen (0-100 cm)	kg ha^{-1}
SMNbasic	:	Basic soil mineral nitrogen (0-100 cm)	kg ha^{-1}
SMNurine	:	Soil mineral nitrogen (0-100 cm) from urine patches	kg ha^{-1}

SMNbasic	=	a +b*EXP(c*(20 + Nunharvested) +d*(20 + Nunharvested)	
SMNbasic	:	Basic soil mineral nitrogen (0-100 cm)	kg ha^{-1}
Nunharvested	:	Nitrogen not harvested in crop	kg ha^{-1}
a	=	-54.5	
b	=	88.3	
c	=	-0.0116678	
d	=	0.774	

SMNurine	=	Nurine * (a +b/(1 + c * Urinedays))	
SMNurine	:	Soil mineral nitrogen (0-100 cm) from urine patches	kg ha^{-1}
Nurine	:	Nitrogen in urine	kg ha^{-1}
Urinedays	:	Days after urination	
a	=	-0.296	
b	=	1.2979	
c	=	0.01841	

5.6.2 Maize land

NO3maize	=	62/14 * SMNmaize * DNF / PRECIPmaize * 10000	
NO3maize	:	Nitrate concentration in groundwater of maize land	mg l^{-1}
SMNmaize	:	Soil mineral nitrogen in 0-100 cm soil layer	kg ha^{-1}
DNF	:	Denitrification factor (Table 51)	
PRECIPmaize	:	Surplus of precipitation on maize land	mm

SMNmaize	=	SUMNW0_60 + SUMNW60_100

SMNmaize	:	Soil mineral nitrogen in 0-100 cm soil layer	kg ha^{-1}
SUMNW0_60	:	Soil mineral nitrogen in 0-60 cm soil layer	
SUMNW60_100	:	Soil mineral nitrogen in 60-100 cm soil layer	

SUMNW0_60	=	a + b * $(SUMNR)^2$	
SUMNW0_60	:	Soil mineral nitrogen in 0-60 cm soil layer	
SUMNR	:	Total applied nitrogen	kg N ha^{-1}
a	=	33.9	
b	=	0.0008459	

SUMNR	=	Nmin + Nfertilizer + Nmanure + Ncc + Npast	
SUMNR	:	Total applied nitrogen	kg N ha^{-1}
Nmin	:	Soil mineral nitrogen in spring	kg N ha^{-1}
Nfertilizer	:	Nitrogen from fertilizer	kg N ha^{-1}
Nmanure	:	Nitrogen from manure	kg N ha^{-1}
Ncc	:	Nitrogen from catch crops	kg N ha^{-1}
Npast	:	Nitrogen from previous applications	

SUMNW60_100	=	a * (b + c*SUMNW0_60 – d*Sqr(SUMNW0_60))	
SUMNW60_100	:	Soil mineral nitrogen in 60-100 cm soil layer	kg N ha^{-1}
SUMNW0_60	:	Soil mineral nitrogen in 0-60 cm soil layer	kg N ha^{-1}
a	=	1.333	
b	=	-0.6	
c	=	0.62	
d	=	0.002069	

6 Energy Use

ENEtotal	=	ENEdirect + ENEindirect	
ENEtotal	:	Total energy use	MJ
ENEdirect	:	Direct energy use	MJ
ENEindirect	:	Indirect energy use	MJ

6.1 Direct energy use

ENEdirect	=	ENEfuel + ENEelec	
ENEdirect	:	Direct energy use	MJ
ENEfuel	:	Energy use from fuel combustion	MJ
ENEelec	:	Energy use from electricity use	MJ

6.1.1 Fuel

ENEfuel	=	a * FUEL	
ENEfuel	:	Energy use from fuel combustion	MJ
FUEL	:	Use of fuel	kg
a	=	48.2	

FUEL	=	EC * AMOUNT	
FUEL	:	Use of fuel	kg
EC	:	Energy coefficient (Table 52)	
AMOUNT	:	Amount (Table 52)	

Table 52 Energy coefficients for various operations (capacity tractor = 75 kW)

Operation	Energy coefficient	Unit coefficient	Amount	Unit amount
Mowing	7.4	kg ha^{-1}	Area mowed	ha
Tedding	4.9	kg ha^{-1}	Area mowed * operations per cut	ha
Windrowing	4.1	kg ha^{-1}	Area mowed	ha
Harvesting	8.5	kg ha^{-1}	Area mowed	ha
Compacting silage heap	5.3	kg ha^{-1}	Area mowed	ha
Grassland rolling	6.3	kg ha^{-1}	Area grassland	ha
Grassland topping	2.5	kg ha^{-1}	Area grassland* operations per year	ha
Grassland, fertilizer application	3.5	kg ha^{-1}	Area grassland* operations per year	ha
Grassland, shallow injection	23.4	kg ha^{-1}	Area grassland* operations per year	ha
Grassland, trailing feet	12.2	kg ha^{-1}	Area grassland* operations per year	ha
Grassland renewal, crop protection	3.0	kg ha^{-1}	Area renewed grassland	ha
Grassland renewal, rotary cutting	35.9	kg ha^{-1}	Area resowed grassland	ha
Grassland renewal, ploughing	28.3	kg ha^{-1}	Area resowed grassland	ha
Grassland renewal, seed bed preparation	11.1	kg ha^{-1}	Area resowed grassland	ha
Grassland renewal, sowing	8.6	kg ha^{-1}	Area renewed grassland	ha
Maize land, ploughing	28.3	kg ha^{-1}	Area maize land	ha
Maize land, cultivating	11.3	kg ha^{-1}	Area maize land	ha
Maize land, seed bed preparation	11.1	kg ha^{-1}	Area maize land	ha
Maize land, rotary cutting	35.9	kg ha^{-1}	Area maize land	ha
Maize land, crop protection	3.0	kg ha^{-1}	Area maize land* operations per year	ha
Maize land, weeding	3.3	kg ha^{-1}	Area maize land* operations per year	ha
Maize land, sowing	3.9	kg ha^{-1}	Area maize land	ha
Maize land, fertilizer application	3.5	kg ha^{-1}	Area maize land* operations per year	ha
Maize land, injection	31.41	kg ha^{-1}	Area maize land	ha
Maize harvest	43.6	kg ha^{-1}	Area maize land	ha
Maize silage compaction	5.3	kg ha^{-1}	Area maize land	ha
Cutting for zero-grazing	5.3	kg time	Summer days * 2	time
Collecting silage for feeding	1.03	kg block^{-1}	Use of kg silage of grass / 375	blocks

6.1.2 Electricity

ENEelec	=	a * ELECtotal	
ENEfuel	:	Energy use from electricity use	MJ
ELECtotal	:	Total use of electricity	kWh
a	=	8.7	

ELECtotal	=	ELECboil + ELECcool + ELECmlk + ELECother	
ELECtotal	:	Total use of electricity	kWh
ELECboil	:	Use of electricity for heating water in boiler	kWh
ELECcool	:	Use of electricity for cooling of milk in milk tank	kWh
ELECmilk	:	Use of electricity for milking	kWh
ELECother	:	Use of electricity for other destination in barn	kWh

ELECboil	=	a * WATERboil * (TEMPboil - b) / (c * RETboil/100)	
ELECboil	:	Use of electricity for heating water in boiler	kWh
WATERboil	:	Amount of heated water to be heated by boiler (Table 53)	l
TEMPboil	:	Temperature of water in boiler	°C
RETboil	:	Return percentage of boiler	%
a	=	4.1868	
b	=	10	
c	=	3600	

Table 53 Water boil

Destination	50 cows (l)	75 cows (l)	100 cows (l)	125 cows (l)
Cleaning milk tubes	150	225	300	375
Cleaning milk tank	75	115	150	190
Other warm water	25	40	65	80
Total	250	380	515	645

ELECcool	=	a * Ncow * MLKprod	
ELECcool	:	Use of electricity for cooling of milk in milk tank	kWh
Ncow	:	Number of cows	cow
MLKprod	:	Milk production per cow	kg cow^{-1}
a	=	14	

ELECmilk	=	a * NMILKAP	
ELECmilk	:	Use of electricity for milking	kWh
NMILKAP	:	Number of milking apparatus	
a	=	800	

ELECother	=	a +b * Ncow	
ELECother	:	Use of electricity for other destination in barn	kWh
Ncow	:	Number of cows	
a	=	1924	
b	=	16.3	

6.2 Indirect energy use

ENEindirect	=	ENEinput + ENEserv + ENEinvest	
ENEindirect	:	Indirect energy use	MJ
ENEinput	:	Indirect energy use from inputs	MJ
ENEserv	:	Indirect energy use from services	MJ
ENEinvest	:	Indirect energy use from investments	MJ

6.2.1 Inputs

ENEinput	=	IEC * AMOUNTpurch	
ENEinput	:	Indirect energy use of input	MJ
IEC	:	Indirect energy coefficient (Table 54)	
AMOUNTpurch	:	Amount purchased	

Table 54 IEC

Input	Energy coefficient	Unit coefficient	Unit amount
Cows	13850	MJ cow^{-1}	cow
Heifers	7985	MJ heifer^{-1}	heifer
Calves	2665	MJ calf^{-1}	calf
Powder of milk	27.8	MJ kg^{-1}	kg
Concentrate (90 DVE)	6.3	MJ kg^{-1}	kg
Concentrate (120 DVE)	5.2	MJ kg^{-1}	kg
Concentrate (180 DVE)	3.9	MJ kg^{-1}	kg
Silage of grass	2.7	MJ kg dm^{-1}	kg dm
Silage of maize	2.7	MJ kg dm^{-1}	kg dm
Fertilizer nitrogen	38.9	MJ kg N	kg N
Fertilizer phosphor	4.3	MJ kg P	kg P
Fertilizer potassium	2.6	MJ kg K	kg K
Manure	280	MJ ton^{-1}	ton
Costs of other fertilizations	4.0	MJ €$^{-1}$	€
Saw dust	0.4	MJ kg^{-1}	kg
Straw	0.8	MJ kg^{-1}	kg
Costs of crop protection	19.2	MJ €$^{-1}$	€
Costs of seeds	19.6	MJ €$^{-1}$	€
Costs of water	5.5	MJ €$^{-1}$	€
Lubricants (5.7% of use of fuel)	46.6	MJ kg^{-1}	kg
Cleaning agent combined	0.7	MJ l^{-1}	l
Cleaning agent acid	0.2	MJ l^{-1}	l
Other product bound costs	5.5	MJ €$^{-1}$	€
Cost of fencing materials	5.5	MJ €$^{-1}$	€
Cover material roughage	11.2	MJ m^{-2}	m^2

6.2.2 Services

ENERserv	=	IEC * COSTSserv	
INDENERserv	:	Indirect energy use of services	MJ
IEC	:	Indirect energy coefficient (Table 55)	MJ €$^{-1}$
COSTserv	:	Costs of services	€

Table 55 Indirect Energy Coefficients for various services

Investment	Energy coefficient (MJ €$^{-1}$)
Costs of contract work	10.6
General costs	5.5
Water board taxes	5.5

6.2.3 Investment

ENEinvest	=	IEC * COSTSinvest	
ENEinvest	:	Indirect energy use of investments	MJ
IEC	:	Indirect energy coefficient (table ?)	MJ €$^{-1}$
COSTinvest	:	Costs of investment	€

Table 56 Indirect Energy Coefficients for various investments

Investment	Energy coefficient (MJ €$^{-1}$)
Depreciation costs housing	7.9
Depreciation costs external storage of manure	7.9
Depreciation costs machinery	9.7
Maintenance costs machinery	8.8
Depreciation costs storage of machinery	7.9
Depreciation costs storage of roughage	7.9
Depreciation costs milk winning equipment	9.7
Maintenance milk winning equipment	8.8
Depreciation costs field road	7.9
Depreciation costs paved path	7.9
Depreciation costs of drainage	7.9

7 Greenhouse gasses

GHGtotal	=	GWP_CH_4.CH_4total + GWP_N_2O. N_2Ototal + CO2total	
GHGtotal	:	Total greenhouse gas emission	kg CO_2-equiv. year^{-1}
GWP_CH_4	:	Global Warming Potential Methane	
GWP_N_2O	:	Global Warming Potential Nitrous oxide	
GWP_CH_4	=	21	
GWP_N_2O	=	310	

7.1 Methane

CH_4total	=	CH_4enteric + CH_4storage + CH_4pasture	
CH_4total	:	Total farm methane emission	kg CH_4 year^{-1}

CH_4enteric	=	a.Iconcentrate + b.Igrass + c.I.maize	
CH_4enteric	:	Methane emission from enteric fermentation	kg CH_4 year^{-1}
Iconcentrate	:	Intake concentrates	kg DM year^{-1}
Igrass	:	Intake grass products	kg DM year^{-1}
Imaize	:	Intake maize silage	kg DM year^{-1}
a	=	20.00	
b	=	19.79	
c	=	16.39	

CH_4storage	=	a.Mstorage	
CH_4storage	:	Methane emission from manure storage	kg CH_4 year^{-1}
Mstorage	:	Manure in storage	kg year^{-1}
a	=	0.001822	

CH_4pasture	=	a.Mpasture	
CH_4pasture	:	Methane emission from manure during grazing	kg CH_4 year^{-1}
Mpasture	:	Manure excretion during grazing	kg year^{-1}
a	=	0.000107	

7.2 Nitrous oxide

N_2Ototal	=	N_2Odirect + N_2Oindirect	
N_2Ototal	:	Total nitrous oxide emission	kg N_2O year^{-1}

N_2Odirect	=	N_2Ostorage + N_2Opasture + N_2Omanure + N_2Ofertilizer + N_2Oresidue + N_2Ohistosols + N_2Orenewal + N_2Ofixation	
N_2Odirect	:	Total direct nitrous oxide emission	kg N_2O year^{-1}

N_2Ostorage	=	a.(Mstorage – NH_3storage) . (44/28)	
N_2Ostorage	:	Nitrous oxide emission from housing and manure storage	kg N_2O year^{-1}
Mstorage	:	Manure in storage	kg N year^{-1}
NH_3storage	:	Ammonia emission from storage	kg N year^{-1}
a	=	0.001	

N_2Opasture	=	a.(Mpasture – NH_3pasture) . (44/28)	
N_2Opasture	:	Nitrous oxide emission from manure excretion during grazing	kg N_2O year^{-1}
Mpasture	:	Manure excretion during grazing	kg N year^{-1}
NH_3pasture	:	Ammonia emission from manure excretion during grazing	kg N year^{-1}
a	=	Table 57	

Table 57 a

Soil type	Groundwater level	a
Mineral soils	I - V	0.0313
	VI	0.0250
	VII - VII*	0.0188
Organic soils	I	0.03
	II - III	0.06
	IV - IV*	0.03

N_2Omanure	=	a.(Mapplied – NH_3application) . (44/28)	
N_2Omanure	:	Nitrous oxide emission from manure application	kg N_2O year^{-1}
Mapplied	:	Manure application	kg N year^{-1}
NH_3application	:	Ammonia emission from manure application	kg N year^{-1}
a	=	Table 58	

Table 58 a

Soil type	Groundwater level	a	
		grassland	Arable land
Mineral soils	I - V	0.0063	0.0125
	VI	0.0050	0.0100
	VII - VII*	0.0038	0.0075
Organic soils	I	0.0050	0.0100
	II - III	0.0100	0.0200
	IV - IV*	0.0050	0.0100

N_2Ofertilizer	=	a.(Nfertilizer – NH_3fertilizer) . (44/28)	
N_2Ofertilizer	:	Nitrous oxide emission from fertilizer application	kg N_2O year^{-1}
Nfertilizer	:	Fertilizer application	kg N year^{-1}
NH_3fertilizer	:	Ammonia emission from fertilizer application	kg N year^{-1}
a	=	Table 59	

Table 59 a

Soil type	Groundwater level	a
Mineral soils	I - V	0.0125
	VI	0.0100
	VII - VII*	0.0075
Organic soils	I	0.0200
	II - III	0.0400
	IV - IV*	0.0200

N_2Oresidue	=	a.Nresidue . (44/28)	
N_2Oresidue	:	Nitrous oxide emission from crop residues	kg N_2O year^{-1}
Nresidue	:	Crop residue	kg N year^{-1}
Nresidue	=	Table 60	kg N year^{-1}
a	=	Table 61	

Table 60 Nresidue

Crop	Nresidue	
	No catch crop	With catch crop
Maize	2	40
Other	40	

Table 61 a

Soil type	Groundwater level	a	
		Maize	Other
Mineral soils	I - V	0.0039	0.0156
	VI	0.0031	0.0125
	VII - VII*	0.0023	0.0094
Organic soils	I	0.0025	0.0100
	II - III	0.0050	0.0200
	IV - IV*	0.0025	0.0100

N_2Ohistosol	=	a.(Ahistosol).(Nmineralisation). (44/28)	
N_2Ohistosol	:	Nitrous oxide emission from agricultural use of histosols	kg N_2O year^{-1}
Ahistosol	:	Area with histosols	ha
Nmineralisation	:	Nitrogen mineralization from histosols	kg N year^{-1}
Nmineralisation	=	235	kg N year^{-1}
a	=	0.02	

N_2Orenewal	=	a.(Arenewal).(Nmineralisation) . (44/28)	
N_2Orenewal	:	Nitrous oxide emission from grassland renewal	kg N_2O year^{-1}
Nmineralisation	:	Nitrogen mineralization after grassland renewal	kg N year^{-1}
Nmineralisation	=	Table 62	kg N year^{-1}
a	=	Table 63	

Table 62 Nmineralisation

Soil type	Nmineralisation
Sand	200
Clay	300
Peat	450

Table 63 a

Soil type	Groundwater level	a	
		Spring	Autumn
Mineral soils	I - V	0.0125	0.0250
	VI	0.0100	0.0200
	VII - VII*	0.0075	0.0150
Organic soils	I	0.0200	0.0400
	II - III	0.0400	0.0800
	IV - IV*	0.0200	0.0400

N_2Ofixation	=	a.(Nfixation) . (44/28)	
N_2Ofixation	:	Nitrous oxide emission from biological fixation	kg N_2O year^{-1}
Nfixation	:	Biological nitrogen fixation	kg N year^{-1}
a	=	Table 64	

Table 64 a

Soil type	Groundwater level	a
Mineral soils	I - V	0.0063
	VI	0.0050
	VII - VII*	0.0038
Organic soils	I	0.0100
	II - III	0.0200
	IV - IV*	0.0100

N_2Oindirect	=	N_2Oleach + N_2Oammonia + N_2Onoxides	
N_2Oindirect	:	Total indirect nitrous oxide emission	kg N_2O year^{-1}

N_2Oleach	=	a.(Nleach) . (44/28)	
N_2Oleach	:	Nitrous oxide emission from leached nitrate	kg N_2O year^{-1}
Nleach	:	Nitrate leaching	kg N year^{-1}
a	=	0.025	

N_2Oammonia	=	a.(NH3losses) . (44/28)	
N_2Oammonia	:	Nitrous oxide emission from ammonia volatilization	kg N_2O year^{-1}
NH3losses	:	Ammonia volatilization	kg N year^{-1}
a	=	0.010	

N_2Onoxides	=	a.(Nnoxides) . (44/28)	
N_2Oammonia	:	Nitrous oxide emission from nitrogen oxides losses	kg N_2O year^{-1}
Nnoxides	:	Nitrogen oxides losses	kg N year^{-1}
a	=	0.010	

7.3 Carbon dioxide

CO2tot	=	a.Electricity + b.Fuel + c.Indirectenergy + d.fertilizer	
CO2tot	:	Total carbon dioxide emission	kg CO2
Electricity	:	Electricity use	GJ
Fuel	:	Fuel consumption	GJ
INdirectenergy	:	Indirect energy use, excluding fertilizer use	GJ
Nfertilizer	:	Fertilizer application	kg N $year^{-1}$
a	=	67	
b	=	73	
c	=	67	
d	=	56	

8 Economy

8.1 Overall financial performance

GMfarm	=	REVtotal - VARCOSTtotal	
GMfarm	:	Gross margin of the farm	€
REVtotal	:	Revenues total	€
VARCOSTtotal	:	Total variable costs	€

GMcontr	=	REVtotal – VARCOSTtotal - COSTcontract	
GMcontr	:	Gross margin of the farm after costs of contract work	€
REVtotal	:	Revenues total	€
VARCOSTtotal	:	Total variable costs	€
COSTcontract	:	Costs of contract work	€

INCOMElabor	=	NETRESfarm – LABORfarmer	
INCOMElabor	:	Income for labor compensation	€
NETRESfarm	:	Net result of farm	€
LABORfarmer	:	Calculated labor costs of farmer	€

NETRESfarm	=	GMfarm - FIXCOSTtotal	
NETRESfarm	:	Net result of farm	€
FIXCOSTtotal	:	Fixed costs	€

COSTPRmilk	=	(COSTVARtotal + COSTFIXtotal – REVlivestock - REVfeed - REVsubsides) / (MILKPROD * Ncow /100)	
COSTPRmilk	:	Cost of producing 100 kg of milk	€ 100 kg^{-1}
VARCOSTtotal	:	Total variable costs	€
FIXCOSTtotal	:	Total fixed costs	€
REVlivestock	:	Revenues from livestock	€
REVfeed	:	Revenues from feed	€
REVsubsidies	:	Revenues from subsidies	€
MILKPROD	:	Milk production	kg cow^{-1}
Ncow	:	Number of cows	cow

8.2 Revenues

REVtotal	=	Revile + REVlivestock + REVfeed + REVsubsides	
REVtotal	:	Revenues total	€
Revile	:	Revenues from milk	€
REVlivestock	:	Revenues from livestock	€
REVfeed	:	Revenues from feed	€
REVsubsidies	:	Revenues from subsidies	€

Revile	=	(MILKPROD * Ncow) * Princely	
REVmilk	:	Revenues from milk	€
MILKPROD	:	Milk production	kg cow^{-1}
Ncow	:	Number of cows	cow
PRICEmlk	:	Price of milk	€ kg^{-1}

REVlivestock	=	Nbullcalf * PRICEbullcalf + (Nheifcalf – Nreqcalf) * PRICEheifcalf + (Ncalf – Nreqheif) * PRICEcalf + (Nheifer – Nccows * REPL/100) * PRICEheifer + Nsoldcow * PRICEcow	
REVlivestock	:	Revenues from livestock	€
Nbullcalf	:	Number of bull calves born alive	calf
Nheifcalf	:	Number of heifer calves born alive	calf
Nreqcalf	:	Number of required calves	calf
Ncalf	:	Number of calves	calf
Nheifer	:	Number of sold heifers (age of 24 months)	heifer
Nccows	:	Number of calving cows	cow
Nsoldcow	:	Number of sold cows	cow
REPL	:	Replacement level of the herd	%
PRICEbullcalf	:	Price of bull calf	€ $calf^{-1}$
PRICEheifcalf	:	Price of heifer calf	€ $calf^{-1}$
PRICEcalf	:	Price of calf (age of 12 months)	€ $calf^{-1}$
PRICEheifer	:	Price of heifer (age of 24 months)	€ $heifer^{-1}$
PRICEcow	:	Price of cow	€ cow^{-1}

REVfeed	=	SURPLUSsg * VEMsg * PRICESsg + SURPLUSsm * VEMsm * PRICESsm	
REVfeed	:	Revenues from feed	€
SURPLUSsg	:	Surplus of silage of grass	ton dm^{-1}
SURPLUSsm	:	Surplus of silage of maize	ton dm^{-1}
VEMsg	:	VEM in silage of grass	VEM kg dm^{-1}
VEMsm	:	VEM in silage of maize	VEM kg dm^{-1}
PRICESsg	:	Selling price silage of grass	€ $kVEM^{-1}$
PRICESsm	:	Selling price silage of maize	€ $kVEM^{-1}$

REVsubsidies	=	5000 + a *(MILKPROD * Ncow) * PREMmilk + COWslaugther * PREMslaugth+ SURFmaize * PREMmaize - 5000)	
REVsubsidies		Revenues from subsidies	€
MILKPROD	:	Milk production	kg cow^{-1}
Ncow	:	Number of cows	cow
COWslaugther	:	Number of slaughtered cows	cow
SURFmaize	:	Area of maize	ha
PREMmilk	:	Premium total of milk	€ kg^{-1}
PREMslaugth	:	Premium of slaughtered cows	€ cow^{-1}
PREMmaize	:	Premium of maize	€ ha^{-1}
a	=	0.95	

8.3 Variable costs

VARCOSTtotal	=	COSTfeed + COSTenergy + COSTprotcrop + COSTfertilizer + COSTseed + COSTmaterial + COSTproduct	
VARCOSTtotal	:	Total variable costs	€
COSTfeed	:	Costs of feed	€
COSTenergy	:	Costs of energy	€
COSTprotcrop	:	Costs of crop protection resources	€
COSTferilizer	:	Costs of fertilizer	€
COSTseed	:	Costs of seeds	€
COSTmaterial	:	Other costs of materials	€
COSTproduct	:	Other product related costs	€

COSTfeed	=	USEmp * PRICEmp + USEconc90 * PRICEconc90 + USEconc120 * PRICEconc120 USEconc180 * PRICEconc180 SHORTsg * VEMsg * PRICEBsg + SHORTsm * VEMsm * PRICEBsm + USEconc90 * PRICEconc90 + USEconc120 * PRICEconc120 + USEconc180 * PRICEconc180 + MISCfeed * Ncow	
COSTfeed	:	Costs of feed	€
USEmp	:	Use of milk powder	kg
USEconc90	:	Use of concentrate 90 DVE	kg
USEconc120	:	Use of concentrate 120 DVE	kg
USEconc180	:	Use of concentrate 180 DVE	kg
SHORTsg	:	Shortage of silage of grass	ton dm^{-1}
SHORTsm	:	Shortage of silage of maize	ton dm^{-1}
VEMsg	:	VEM in silage of grass	VEM kg dm^{-1}
VEMsm	:	VEM in silage of maize	VEM kg dm^{-1}
MISCfeed	:	Miscellaneous feed costs	€ cow^{-1}
Ncow	:	Number of cows	cow
PRICEmp	:	Price of milk powder	€ kg^{-1}
PRICEconc90	:	Price of concentrate 90 DVE	€ kg^{-1}
PRICEconc120	:	Price of concentrate 120 DVE	€ kg^{-1}
PRICEconc180	:	Price of concentrate 180 DVE	€ kg^{-1}
PRICEBsg	:	Buying price silage of grass	€ $kVEM^{-1}$
PRICEBsm	:	Buying price silage of maize	€ $kVEM^{-1}$

COSTenergy	=	FIXelec + ELECtotal * a1 * PRICEelech + ELECtotal * a2 * PRICEelecl	
COSTenergy	:	Costs of energy	€
ELECtotal	:	Use of electricity	kWh
FIXelec	:	Fixed costs electricity supply	€
PRICEelech	:	Price of energy high rate	€ kWh^{-1}
PRICEelecl	:	Price of energy low rate	€ kWh^{-1}
a1	=	0.8	
a2	=	0.2	

COSTprotcrop	=	SURFgrass * COSTprotgr + SURFrenew * COSTprotrenew + SURFmaize * COSTprotmaize	
COSTprotcrop	:	Costs of crop protection resources	€
SURFgrass	:	Area of grassland	ha
SURFrenew	:	Area of renewed grassland	ha
SURFmaize	:	Area of maize land	ha
COSTprotgr	:	Cost of crop protection grassland	€ ha^{-1}
COSTprotrenew	:	Cost of crop protection grassland renewed	€ ha^{-1}
COSTprotmaize	:	Cost of crop protection maize land	€ ha^{-1}

COSTfertilizer	=	(SURFgrass * Ngrass + SURFmaize * Nmaize – Nmanur) * PRICEfertn+ (SURFgrass * Pgrass + SURFmaize * Pmaize – Pmanur) * PRICEfertp+ (SURFgrass * Kgrass + SURFmaize * Kmaize – Kmanur) * PRICEfertk+ SURFgrass * FERTotherg + SURFmaize * FERTotherm	
COSTfertilizer	:	Costs of fertilizer	€
SURFgrass	:	Area of grassland	ha
SURFmaize	:	Area of maize land	ha
Ngrass	:	Nitrogen from fertilizer and manure on grassland	kg ha^{-1}
Pgrass	:	Phosphor from fertilizer and manure on grassland	kg ha^{-1}
Kgrass	:	Potassium from fertilizer and manure on grassland	kg ha^{-1}
Nmaize	:	Nitrogen from fertilizer and manure on maize land	kg ha^{-1}
Pmaize	:	Phosphor from fertilizer and manure on maize land	kg ha^{-1}
Kmaize	:	Potassium from fertilizer and manure on maize land	kg ha^{-1}
Nmanur	:	Working nitrogen from manure	kg
Pmanur	:	Working phosphor from manure	kg
Kmanur	:	Working potassium from manure	kg
PRICEfertn	:	Price of fertilizer nitrogen	€ kg N
PRICEfertp	:	Price of fertilizer phosphor	€ kg P
PRICEfertk	:	Price of fertilizer potassium	€ kg K
FERTotherg	:	Costs of other fertilizers on grassland	€ ha^{-1}
FERTotherm	:	Costs of other fertilizers on maize land	€ ha^{-1}

COSTseed	=	SURFrenew * COSTseedgrass + SURFmaize * COSTseedmaize	
COSTseed	:	Costs of seeds	€
SURFrenew	:	Area of renewed grassland	ha
SURFmaize	:	Area of maize land	ha
COSTseedgr	:	Cost of seed grassland	€ ha^{-1}
COSTseedmaize	:	Cost of seed maize land	€ ha^{-1}

COSTmaterial	=	FIXwater + (WATERdrink + WATERclean) * Ncow * PRICEwater + USEclcomb * PRICEclcomb + USEclacid * PRICEclacid + SURFplastic * PRICEplastic + SURFgrass * PRICEfencing + (USEstrcow * Ncow + USEstrheif * Nheifer + USEstrcalf * Ncalf) * PRICEstr/1000	
COSTmaterial	:	Other costs of materials	€
WATERdrink	:	Use of drinking water indoor (Table 65)	m^3 cow^{-1}
WATERclean	:	Use of cleaning water (Table 65)	m^3 cow^{-1}
Ncow	:	Number of cows	cow
USEclcomb	:	Use of cleaning agent combined (Table 65)	m^3
USEclacid	:	Use of cleaning agent acid (Table 65)	m^3
SURFplastic	:	Surface of used plastic for storage of roughage	m^2
USEstrcow	:	Use of straw by cows (Table 65)	kg cow^{-1}
USEstrheif	:	Use of straw by heifers (Table 65)	kg $heifer^{-1}$
USEstrcalf	:	Use of straw by calves (Table 65)	kg $calf^{-1}$
FIXwater	:	Fixed costs of water supply	€
Ncow	:	Number of cows	cow
Nheifer	:	Number of heifers	heifer
Ncalf	:	Number of calves	calf
PRICEwater	:	Price of water	€ m^{-3}
PRICEclcomb	:	Price of cleaning agent combined	€ m^{-3}
PRICEclacid	:	Price of cleaning agent acid	€ m^{-3}
PRICEplastic	:	Price of plastic	€ m^{-2}
PRICEfencing	:	Costs of fencing grassland	€ ha^{-1}
PRICEstr	:	Price of straw	€ ton^{-1}

Table 65 Miscellaneous material use

Material	Use of materials	
Drinking water	30	m^3 cow^{-1}
Cleaning water	5.5	m^3 cow^{-1}
Cleaning agent combined	245	m^3 cow^{-1}
Cleaning agent acid	24	m^3
Straw cows	100	kg cow^{-1}
Straw heifers	65	kg $heifer^{-1}$
Straw calves	140	kg $calf^{-1}$

COSTproduct	=	PRICEvetadv * Ncow + PRICEvetcow * Ncow * MILKPROD/100 + PRICEvetheif * Nheifer + COSTvetcalf * Ncalf + PRICEclaw * Ncow + PRICEshcow * Ncow + PRICEshys * (Nheifers+Ncalf) + PRICEmlkcontr * Ncow + PRICEinsemen * Nccow+Nheifer	
COSTproduct	:	Other product bound costs	€
COSTvetadv	:	Veterinarian costs of advice	€ cow^{-1}
Nccow	:	Number of calving cows	cow
Nheifer	:	Number of heifers	heifer
Ncalf	:	Number of calves	calf
PRICEvetcow	:	Veterinarian costs per 100 kg milk	€ 100 kg^{-1}
PRICEvetheif	:	Veterinarian costs per heifer	€ $heifer^{-1}$
PRICEvetcalf	:	Veterinarian costs per calf	€ $calf^{-1}$
PRICEclaw	:	Costs of claw care	€ cow^{-1}
PRICEshcw	:	Costs of shaving cows	€ cow^{-1}
PRICEshys	:	Costs of shaving young stock	€ $youngstock^{-1}$
PRICEmlkcontr	:	Costs of milking registration	€ cow^{-1}
PRICEinsemen	:	Costs of insemination	€ cow^{-1}

8.4 Fixed costs

FIXCOSTtotal	=	COSTlabor + COSTcontract + COSTdepr + COSTmachine + COSTimmov + COSTgeneral + COSTinterest	
FIXCOSTtotal	:	Total fixed costs	€
COSTlabor	:	Costs of labor	€
COSTcontract	:	Costs of contract work	€
COSTdepr	:	Depreciation costs of investments	€
COSTmachine	:	Costs of machinery	€
COSTimmov	:	Costs of immovable's	€
COSTgeneral	:	General costs	€
COSTinterest	:	Costs of calculated interest	€

8.4.1 Labor

LABORfamer	=	Nfarmer * PRICE farmer	
LABORfarmer	:	Calculated labor costs of farmer	€
Nfarmer	:	Number of farmers	€
PRICE farmer	:	Labor costs of farmer	€ VAK^{-1}

COST labor	=	LABOR farmer + LABOR family + Npersonnel * PRICEpers + LABORHIRE * PRICElabhire + MISClabor	
COST labor	:	Costs of labor	€
LABOR farmer	:	Calculated labor costs of farmer	€
LABOR family	:	Labor costs of partner and children of farmer	€
Npersonnel	:	Number of personnel	VAK
LABORHIRE	:	Number of hired labor hours	hour
MISClabor	:	Miscellaneous amount of labor	€
PRICEpers	:	Labor cost of personnel	€ VAK^{-1}
PRICElabhire	:	Labor costs of hired workers	€ $hour^{-1}$

8.4.2 Contract work

COST contract	=	PRICEspray * AREA grass * PERCrenewal/100 * NUMGspray +	
		PRICEplough * AREAgrass * PERCrenewal/100 * a	
		PRICErotor cult * AREAgrass * PERCrenewal/100 * a +	
		PRICErotor level * AREAgrass * PERCrenewal/100 * a +	
		PRICEsow * AREAgrass * PERCrenewal/100 +	
		PRICEmow * AREAgrass * PERCmowing/100 +	
		PRICEgrassharv * AREAgrass * PERCmowing/100 +	
		PRICEride * AREAgrass * PERCmowing/100 +	
		PRICEgrcarry * AREAgrass	
		PRICEspray * AREAmaize * NUMMspray +	
		PRICEplough * AREAmaize +	
		PRICElevel * AREAmaize +	
		PRICEcultiv * AREAmaize +	
		PRICEsow * AREAmaize +	
		PRICE harrow * AREAmaize * NUMMharrow +	
		PRICE hoe * AREAmaize NUMMhoe +	
		PRICEmaizeharv * AREAmaize +	
		PRICEride * AREAgrass * PERCmowing/100 +	
		PRICEccrop * AREAccrop +	
		PRICEgrassharv * AREAcachcrop +	
		PRICEshallow * MANUREshallow +	
		PRICEband * MANUREband +	
		PRICEincorp * MANUREincorp +	
		PRICEinject * MANUREinject +	
		PRICEmaint * (AREAgrass + AREAmaize)	
COSTcontract	:	Costs of contract work	€
AREAgrass	:	Area of grass land	ha
AREAmaize	:	Area of maize land	ha
AREAccrop	:	Area of catch crop	ha
PERCrenewal	:	Percentage of grassland renewed every year	%
PERCmowing	:	Percentage of grassland mowed	%
NUMGspray	:	Number of spraying at renewal of grassland	count
NUMMspray	:	Number of spraying on maize land	count
NUMMharrow	:	Number of harrowing on maize land	count
NUMMhoe	:	Number of hoeing on maize land	count
MANUREshallow	:	Amount of manure applied by shallow open-slot injectiing	m^3
MANUREband	:	Amount of manure applied by band spreading with trailing feet	m^3
MANUREincorp	:	Amount of manure applied by incorporating	m^3
MANUREinject	:	Amount of manure applied by injectiing	m^3
PRICEspray	:	Contract work price of spraying	€ ha^{-1}
PRICEplough	:	Contract work price of ploughing	€ ha^{-1}
PRICErotor cult	:	Contract work price of rotor cultivating	€ ha^{-1}
PRICErotor level	:	Contract work price of rotor levelling	€ ha^{-1}
PRICEcultiv	:	Contract work price of cultivating maize land	€ ha^{-1}
PRICE harrow	:	Contract work price of harrowing maize land	€ ha^{-1}
PRICElevel	:	Contract work price of levelling maize land	€ ha^{-1}
PRICEsow	:	Contract work price of sowing maize land	€ ha^{-1}
PRICEccrop	:	Contract work price of sowing a catch crop	€ ha^{-1}
PRICE hoe	:	Contract work price of hoeing maize land	€ ha^{-1}
PRICEmow	:	Contract work price of mowing	€ ha^{-1}
PRICEgrassharv	:	Contract work price of harvesting grass silage	€ ha^{-1}
PRICEride	:	Contract work price of riding on silage stacks	€ ha^{-1}
PRICEgrcarry	:	Contract work price of carrying of grassland	€ ha^{-1}
PRICEmaizeharv	:	Contract work price of harvesting silage of maize	€ ha^{-1}
PRICEshallow	:	Contract work price of applying manure by shallow open-slot injectiing	€ m^{-3}
PRICEband	:	Contract work price of applying manure by band spreading with trailing feet	€ m^{-3}
PRICEincorp	:	Contract work price of applying manure by incorporating	€ m^{-3}
PRICEinject	:	Contract work price of applying manure by injecting	€ m^{-3}
PRICEmaint	:	Contract work price of maintaince of land	€ ha^{-1}
a		0.5	

8.4.3 Animals and land

REPVALherd	=	VALUEcow * Ncow + VALUEheif * Nheifer + VALUEcalf * Ncalf	
REPVAL	:	Replacement value of the herd	€
Ncow	:	Number of cows	cow
Nheifer	:	Number of heifers	heifer
Ncalf	:	Number of calves	calf
VALUEcow	:	Value of a cow (Table 66)	€ cow^{-1}
VALUEheifer	:	Value of a heifer (Table 66)	€ heifer^{-1}
VALUEcalf	:	Value of a calf (Table 66)	€ calf^{-1}

Table 66 Values of animals and land

	Value (€)
Cow	275
Heifer	700
Calf	1050
Land (ha)	14250

REPVALland	=	VALUEland * (1 + AREAgrass AREAmaize)	
REPVAL	:	Replacement value of the herd	€
AREAgrass	:	Area of grassland	ha
SURFACmaize	:	Area of maize land	ha
VALUEland	:	Value of land (Table 66)	€ calf^{-1}

8.4.4 Buildings

REPVALbuild	=	a * Exp(c0 + b1 * STMANURE + b2 * STMANURE * STMANURE + b3 * STMANURE * Ncow + b4 * Ncow + b5 * Ncow * Ncow + b6 * Ncow * Ncow * Ncow + b7 * YSHOUSE + b8 * WAITAREA + b9 * FOUNDhei + b10 * ENTRYdouble + b11 * Ncow * YSHOUSE + b12 * Ncow * WAITAREA + b13 * Ncow * FOUNDhei + b14 * Ncow * ENTRYdouble + b15 * c1 + b16 * STMANURE * (FOUNDhei + 1) + b17 * YSHOUSE * WAITAREA + b18 * WAITAREA * ENTRYdouble + b19 * WAITAREA * c1 + b20 * STMANURE * c2)	
REPVALbuild	:	Replacement value of the building	€
STMANURE	:	Storage of manure below housing	month
Ncow	:	Number of cows	cow
YSHOUSE	:	Young stock in housing (0 = yes, 1 = no)	0,1
WAITAREA	:	Separate waiting area in housing (0 = yes, 1 = no)	0,1
ENTRYdouble	:	Double entry for feeding zone (0 = yes, 1 = no)	0,1
FOUNDhei	:	Foundation of housing “geheid” (0 = yes, 1 = no)	0,1
a	=	1.983	
b1 to b20, c0 to c2	=	Table 67	

Table 67 b1...b20, c0...c2

Coefficient	Rows in stable 1+1	Rows in stable 2+1	Rows in stable 2+2	Rows in stable 3+1
b1	0.03317	0.07665	0.07665	0.11656
b2	-0.002871	-0.004656	-0.004656	-0.006423
b3	0.0003256	0.00008923	0.00008923	0.0000793
b4	0.04442	0.017510	0.017510	0.02706
b5	-0.0004370	-0.000044937	-0.000044937	-0.0001300
b6	0.000001825	0	0	0.00000025594
b7	0.27527	0.36415	0.36415	0.37430
b8	0.02863	0.04542	0.04542	-0.00060
b9	0.16444	0.26316	0.26316	0.25539
b10	0.12971	0.02169	0.02169	0
b11	0.001675	0.0003716	0.0003716	0
b12	0.000163	0	0	0
b13	0.000781	0	0	0
b14	-0.000116	0	0	0
b15	0	0.030716	0.030716	0.03384
b16	0	-0.010231	-0.010231	0.008780
b17	0	-0.01732	-0.01732	0
b18	0	0.01117	0.01117	0
b19	0	0	0	0.03196
b20	0	0	0	-0.007884
c0	9.7493	10.32386	10.32386	9.9813
c1	0	1	0	1
c2	0	0	0	4

8.4.5 Milking equipment

Table 68 Replacement value of milking equipment at 3 levels of automation

Type	Number of cows/ side	Value at level of automation = LOW (€)	Value at level of automation = NORMAL (€)	Value at level of automation = HIGH (€)
Open	8	64500	83000	91000
	10	80000	103000	110000
Side by side	12	42000	61500	69000
	24	71000	110000	117500
Herringbone	12	43500	63000	70500
	24	73000	112500	120000

8.4.6 External storage of manure

REPVALstorman	=	Nstorman * (VALsiloman + VALcoversilo) * a / b	
REPVALstorman	:	Replacement value of external storages of manure	€
Nstorman	:	Number of external storages of manure	
VALsiloman	:	Value of external silo for manure	€
VALcoversilo	:	Value of cover of external silo for manure	€
a	=	198.3	
b	=	279.3	

VALsiloman	=	a + b1*(HEIGHTsilo+ c) + b2*DIAMsilo*DIAMsilo + b3*DIAMsilo + b4*CAPsilo	
VALsiloman	:	Value of external silo for manure	€
HEIGHTsilo	:	Height of external manure storage	m
DIAMsilo	:	Diameter of external storage of manure	m
CAPsilo	:	Capacity of external storageof manure	m^3
a, b1...4, c	=	Table 69	

Table 69 a, b1,b2,b3,b4,c

Coefficient	Foundation = sand	Foundation = Hei
c	-15053.1	-15060.6
b1	5784.055	6293.125
b2	0.0	83.12376
b3	1832.98	1922.609
b4	18.78858	32.46618
c	0.2	0.2

VALcoversilo	=	a + b1 * DIAMsilo + b2 * DIAMsilo	
VALcoversilo	:	Value of cover of external silo for manure	€
DIAMsilo	:	Diameter of external storage of manure	m
a, b1, b2	=	Table 70	

Table 70 a, b1, b2

Coefficient	Cover = Floating	Cover = Roof	Cover = Tent	Cover = Plate
a	7003.071	8819.35	49673.53	8864.327
b1	0.0	0.0	-3560.49	-5.00668
b2	36.66865	81.48407	128.3136	81.60254

8.4.7 Storage of roughage

REPVALstorrough	=	Nstorgrass * VALstorgrass + Nstormaize * VALstormaize	
REPVALstorrough	:	Replacement value of storage of roughage	€
VALstorgrass	:	Value of silo of silage of grass	€
VALstormaize	:	Value of silo of silage of maize	€
Nstorgrass	:	Number of storages of silage of grass	
Nstormaize	:	Number of storages of silage of maize	

VALstorgrass	=	(LENGTHstack + LENGTHdrive +1.0) * (WIDTHstack + 1.0) * PRICEstorloor	
VALstorgrass	:	Value of storage of grass silage	€
LENGTHstack	:	Length of silage stack plus extra length for driving	m
LENGTHdrive	:	Extra length for driving	m
WIDTHstack	:	Width of silage stack	m
PRICEstorfloor	:	Price of floor of storage	€ m^{-2}

Table 71 Measurements of silage storages at different amounts of dry matter silage of grass per meter

Covered with soil	Silage (kg DM m^{-1})	Height (m)	Width (m)	Extra length drive (m)
Yes	445.0	0.75	4.0	1.75
	570.0	1.00	4.0	2.00
	760.0	1.00	5.0	2.00
	915.0	1.25	5.0	2.25
	950.0	1.00	6.0	2.00
	1150.0	1.25	6.0	2.25
	1405.0	1.25	7.0	2.25
	1700.0	1.50	7.0	2.50
	1640.0	1.25	8.0	2.25
	2010.0	1.50	8.0	2.50
	2155.0	1.50	8.5	2.50
No	445.0	0.75	4.0	2.0
	595.0	1.00	4.0	2.0
	835.0	1.00	5.0	2.0
	980.0	1.25	5.0	2.5
	935.0	1.00	6.0	2.0
	1175.0	1.25	6.0	2.5
	1445.0	1.50	6.0	3.0
	1105.0	1.00	7.0	2.0
	1385.0	1.25	7.0	2.5
	1720.0	1.50	7.0	3.0
	2000.0	1.50	8.0	3.0
	2495.0	1.80	8.0	3.5
	2635.0	1.80	8.5	3.5
	3040.0	2.10	8.5	4.0
	3275.0	2.10	9.0	4.0

VALstormaize	=	LENGTHsilo * WIDTHsilo * PRICEstorfloor + (HEIGHTwall * 2 * LENGTHsilo) * PRICEsilowall + (HEIGHTsilo * WIDTHsilo) * PRICEsilowall	
VALstormaize	:	Value of storage of silage of maize	€
LENGTHsilo	:	Length of silo plus extra length for driving	m
WIDTHsilo	:	Width of silo	m
HEIGHTwall	:	Height of the wall of silo	m
PRICEstorfloor	:	Price of floor of silo	€ m^{-2}
PRICEsilowall	:	Price of wall of silo	€ m^{-2}

Table 72 Measurements of silage storages at different amounts of dry matter silage of grass per meter

Covered with soil	Silage (kg DM m^{-1})	Height of silo (m)	Width of silo (m)	Height of wall (m)
Yes	1230.0	1.05	6.0	0.75
	1320.0	1.10	6.0	0.80
	1600.0	1.30	6.0	1.00
	1435.0	1.05	7.0	0.75
	1540.0	1.10	7.0	0.80
	1865.0	1.30	7.0	1.00
	2205.0	1.50	7.0	1.20
	1640.0	1.05	8.0	0.75
	1760.0	1.10	8.0	0.80
	2130.0	1.30	8.0	1.00
	2520.0	1.50	8.0	1.20
	3095.0	1.80	8.0	1.50
	1980.0	1.10	9.0	0.80
	2400.0	1.30	9.0	1.00
	2835.0	1.50	9.0	1.20
	3485.0	1.80	9.0	1.50
	2665.0	1.30	10.0	1.00
	3150.0	1.50	10.0	1.20
	3870.0	1.80	10.0	1.50
No	1135.0	1.05	6.0	0.75
	1220.0	1.10	6.0	0.80
	1480.0	1.30	6.0	1.00
	1325.0	1.05	7.0	0.75
	1425.0	1.10	7.0	0.80
	1730.0	1.30	7.0	1.00
	2050.0	1.50	7.0	1.20
	1510.0	1.05	8.0	0.75
	1630.0	1.10	8.0	0.80
	1975.0	1.30	8.0	1.00
	2340.0	1.50	8.0	1.20
	2880.0	1.80	8.0	1.50
	1830.0	1.10	9.0	0.80
	2225.0	1.30	9.0	1.00
	2635.0	1.50	9.0	1.20
	3240.0	1.80	9.0	1.50
	3875.0	2.10	9.0	1.50
	2470.0	1.30	10.0	1.00
	2925.0	1.50	10.0	1.20
	3600.0	1.80	10.0	1.50
	4305.0	2.10	10.0	1.50

8.4.8 Miscellaneous storage

REPVALmisc	=	SURFACEstmach * PRICEstmach + SURFACEgaragae* PRICEgarage + SURFACEststraw * PRICEststraw	
REPVALmisc	:	Replacement value of miscelleaneous storage	€
SURFACEstmach	:	Surface of storage of machines	m^2
SURFACEgarage	:	Surface of garage	m^2
SURFACEststraw	:	Surface of storage of straw	m^2
PRICEstmach	:	Price of investments of storage of machines	€ m^{-2}
PRICEgarage	:	Price of investments of garage	€ m^{-2}
PRICEststraw	:	Price of investments of storage of straw	€ m^{-2}

8.4.9 Field road

REPVALroad	=	a + (AREAgrass * b)	
REPVALroad	:	Replacement value of field road	€
AREAgrass	:	Area of grassland	ha
PRICEroad	:	Price of investments of field road	€ m^{-1}
a	=	50	
b	=	20	

8.4.10 Paved path

REPVALlpavpath	=	(LENGTHfarm * a + b * (WIDTHfarm+c) + LENGTHentr* WIDTHentr) * PRICEpavpath	
REPVALlpavpath	:	Replacement value of paved path	€
WIDTHfarm	:	Width of the farm	m
LENGTHfarm	:	Length of the farm	m
WIDTentr	:	Width of the entrance road	m
LENGTHentr	:	Length of the entrance road	m
PRICEpavpath	:	Price of investments of pave path	€ m^{-2}
a	=	3	m
b	=	20	m
c	=	6	m

8.4.11 Drainage

REPVALdrain	=	AREAdrain * (((100.0 / DRAINdist) - 1.0) * 100.0) * PRICEdrain	
REPVALldrain	:	Replacement value of drainage	€
AREAdrain	:	Area of land drained	ha
DRAINdist	:	Distance between drains	m
PRICEdrain	:	Price of a drain	€ m^{-2}

Table 73 Percentages of investment costs

Investment	Depreciation (%)	Maintenance (%)	Rest value (%)
Building	5	2	0
Machinery	9	4	10
Milking area and equipment	11	5	10
External storage of manure	5	2.5	0
Storage of roughage	5	1.5	0
Misc storage	5	1	0
Field road	3	0.5	0
Paved path	3	0.5	0
Drainage	3	1	0

DEPR	=	REPVAL * PERCdepr / 100.0	
DEPR	:	Depreciation costs of investments	€
REPVAL	:	Replacement value of investment	€
PERCdepr	:	Percentage of depreciation of investment (table ?)	%

MAINT	=	REPVAL * PCmaint / 100.0	
MAINT	:	Maintaince costs of investments	€
REPVAL	:	Replacement value of investment	€
PERCmaint	:	Percentage of maintenance of investment (table ?)	%

INT	=	PERCinterest/100.0 * ((1.0 + (PERCrest / 100.0)) / 2.0) * REPVAL	
INT	:	Interest costs of investments	€
REPVAL	:	Replacement value of investment	€
PERCrest	:	Percentage of rest value of investment (table ?)	%
PERCinterest	:	Percentage of interest	%

COSTdepr	=	DEPRbuild + DEPRmachinery + DEPRmilkequip + DEPRstormanure +DEPRstorrough + DEPRstormach + DEPRlotpath + DEPRpavpath + DEPRdrain	
COSTdepr	:	Depreciation costs of investments	€
DEPRbuild	:	Depreciation costs of investment in building	€
DEPRmachinery	:	Depreciation costs of investment in machinery	€
DEPRmilkequip	:	Depreciation costs of investment in milk area and equipment	€
DEPRstormanure	:	Depreciation costs of investment in external storage of manure	€
DEPRstorrough	:	Depreciation costs of investment in storage of roughage	€
DEPRstormisc	:	Depreciation costs of investment in miscellaneous storage	€
DEPRlotpath	:	Depreciation costs of investment in field road	€
DEPRpavpath	:	Depreciation costs of investment in pavement path	€
DEPRdrain	:	Depreciation costs of investment in drainage	€

COSTmachine	=	USEfuel * PRICEfuel + MAINTmachinery + MAINTmilkquip	
COSTmachine	:	Costs of machinery	€
USEfuel	:	Use of fuel	kg
MAINTmachinery	:	Maintenance costs of machinery	€
MAINTmilkquip	:	Maintenance costs of milk area and equipment	€
PRICEfuel	:	Price of fuel	€ kg^{-1}

COSTimmov	=	TAXpolderwater + TAXimmov + MAINTbuild + MAINTstormanure +MAINTstorrough + MAINTstormisc + MAINTroad + MAINTpavpath + MAINTdrain	
COSTimmov	:	Costs of immovable's	€
TAXpolderwater	:	Tax costs of polder and water use	€
TAXimmov		Tax costs of immovable's	€
MAINTbuild	:	Maintenance costs of investment in buildings	€
MAINTstormanure	:	Maintenance costs of investment in external storage of manure	€
MAINTstorrough	:	Maintenance costs of investment in storage of roughage	€
MAINTstormisc	:	Maintenance costs of investment in miscellaneous storage	€
MAINTroad	:	Maintenance costs of investment in field road	€
MAINTpavpath	:	Maintenance costs of investment in pavement path	€
MAINTdrain	:	Maintenance costs of investment in drainage	€

TAXpolderwater	=	PRICEpwground * (AREAgrass + AREAmaize + 1) + PRICEpwbuild / b * (a + REPVALbuild + REPVALstormisc + REPVALstormanure + REPVALstorrough + REPVALpavpath)	
TAXpolderwater	:	Tax costs of polder and water use	€
AREAgrass	:	Area of grassland	ha
AREAmaize	:	Area of maize land	ha
PRICEpwground	:	Price of polder and water tax of ground	€ ha^{-1}
PRICEpwbuild	:	Price of polder and water tax of buildings (per 2268 €)	€ $taxunit^{-1}$
REPVALbuiild	:	Replacement value of investment in buildings	€
REPVALstormanure	:	Replacement value of investment in external storage of manure	€
REPVALstorrough	:	Replacement value of investment in storage of roughage	€
REPVALstormisc	:	Replacement value of investment in miscellaneous storage	€
REPVALpavpath	:	Replacement value of investment in pavement path	€
a	=	14250	
b	=	2268	

TAXimmov	=	PRICEimmov / b * (a + REPVALbuild + REPLVstormanure + REPVALstorrough + REPVALstormisc + REPVALpavpath)	
TAXimmov		Tax costs of immovable's	€
PRICEimmov	:	Price of tax of immovable's (per 2268 €)	€ taxunit^{-1}
REPVALbuild	:	Replacement value of investment in building	€
REPVALstormanure	:	Replacement value of investment in external storage of manure	€
REPVALstorrough	:	Replacement value of investment in storage of roughage	€
REPVALstormisc	:	Replacement value of investment in miscellaneous storage	€
REPVALpavpath	:	Replacement value of investment in pavement path	€
a	=	14250	
b	=	2268	

COSTgeneral	=	a + b * Ncow + c * Nheifer + d * Ncalf	
COSTgeneral	:	General costs	€
Ncow	:	Number of cows	cow
Nheifer	:	Number of heifers	heifer
Ncalf	:	Number of calves	calf
a	=	10900	€
b	=	1.33	€ cow^{-1}
c	=	1.33	€ heifer^{-1}
d	=	0.64	€ calf $^{-1}$

COSTinterest	=	AREAmaize * PRICEintmaize + INTherd + INTland + INTbuild + INTmachinery + INTmilkequip + INTstormanure + INTstorrough + INTstormisc + INTroad + INTpavpath + INTdrain	
COSTinterest	:	Costs of calculated interest	€
AREAmaize	:	Area of maize	ha
PRICEintmaize	:	Price of interest of the maize	€ ha^{-1}
INTherd	:	Interest costs of the herd	€
INTland	:	Interest costs of investment in land	€
INTbuild	:	Interest costs of investment in building	€
INTmachinery	:	Interest costs of investment in machinery	€
INTmilkequip	:	Interest costs of investment in milk area and equipment	€
INTstormanure	:	Interest costs of investment in external storage of manure	€
INTstorrough	:	Interest costs of investment in storage of roughage	€
INTstormisc	:	Interest costs of investment in miscellaneous storage	€
INTroad	:	Interest costs of investment in field road	€
INTpavpath	:	Interest costs of investment in pavement path	€
INTdrain	:	Interest costs of investment in drainage	€

8.5 Prices

Table 74 Prices and costs of various products

			Price	Unit price
PRICEmlk	:	Price of milk	28.67	€ 100 kg^{-1}
PRICEbullcalf	:	Price of bull calf	150	€ calf^{-1}
PRICEheifcalf	:	Price of heifer calf	95	€ calf^{-1}
PRICEcalf	:	Price of calf (12 months)	450	€ calf^{-1}
PRICEheifer	:	Price of heifer (24 months)	950	€ heifer^{-1}
PRICEcow	:	Price of cow	490	€ cow^{-1}
PRICESsg	:	Selling price silage of grass	0.06	€ kVEM^{-1}
PRICESsm	:	Selling price silage of maize	0.08	€ kVEM^{-1}
PREMmilk	:	Premium of milk	3.54	€ 100 kg^{-1}
PREMslaugth	:	Premium of slaughtered cows	114	€ cow^{-1}
PREMmaize	:	Premium of maize	420	€ ha^{-1}
PRICEmp	:	Price of milk powder	125	€ 100 kg^{-1}
PRICEconc90	:	Price of concentrate 90 DVE	14	€ 100 kg^{-1}
PRICEconc120	:	Price of concentrate 120 DVE	15.5	€ 100 kg^{-1}
PRICEconc180	:	Price of concentrate 180 DVE	18.5	€ 100 kg^{-1}
PRICEBsg	:	Buying price silage of grass	0.06 +	€ kVEM^{-1}
PRICEBsm	:	Buying price silage of maize	0.08 +	€ kVEM^{-1}
FIXelec	:	Fixed costs electricity supply	80	€
PRICEelech	:	Price of energy high rate	0.13	€ kWh^{-1}
PRICEelecl	:	Price of energy low rate	0.07	€ kWh^{-1}
COSTprotgr	:	Cost of crop protection grassland	9	€ ha^{-1}
COSTprotrenew	:	Cost of crop protection grassland renewed	65	€ ha^{-1}
COSTprotmaize	:	Cost of crop protection maize land	100	€ ha^{-1}
PRICEfertn	:	Price of fertilizer nitrogen	0.69	€ kg N
PRICEfertp	:	Price of fertilizer phosphor	0.24	€ kg P
PRICEfertk	:	Price of fertilizer potassium	0.29	€ kg K
FERTotherg	:	Costs of other fertilizers on grassland	62	€ ha^{-1}
FERTotherm	:	Costs of other fertilizers on maize land	57	€ ha^{-1}
COSTseedgr	:	Cost of seed grassland	130	€ ha^{-1}
COSTseedmaize	:	Cost of seed maize land	190	€ ha^{-1}
FIXwater	:	Fixed costs of water supply	45	€
PRICEwater	:	Price of water	1.1	€ m^{-3}
PRICEclcomb	:	Price of cleaning agent combined	1.0	€ m^{-3}
PRICEclacid	:	Price of cleaning agent acid	2.2	€ m^{-3}
PRICEplastic	:	Price of plastic for cover of roughage	0.32	€ m^{-2}
PRICEfence	:	Price for fencing grassland	75	€ ha^{-1}
PRICElit	:	Price of saw dust	150	€ ton^{-1}
PRICEvetadv	:	Veterinarian costs of advice	13.5	€ cow^{-1}
PRICEvetcow	:	Veterinarian costs per 100 kg milk	0.83	€ 100 kg^{-1}
PRICEvetheif	:	Veterinarian costs per heifer	19.4	€ heifer^{-1}
PRICEvetcalf	:	Veterinarian costs per calf	43.85	€ calf^{-1}
PRICEclaw	:	Costs of claw care	9.25	€ cow^{-1}
PRICEshcw	:	Costs of shaving cows	7.4	€ cow^{-1}
PRICEshys	:	Costs of shading young stock	4.95	€ youngstock^{-1}
PRICEmlkcontr	:	Costs of milking registration	27.5	€ cow^{-1}
PRICEinsemen	:	Costs of insemination	34.75	€ cow^{-1}
PRICEfarmer	:	Calculated labor costs of farmer	47400	€ VAK^{-1}
PRICEpers	:	Labor cost of personnel	32630	€ VAK^{-1}
PRICElabhire	:	Labor costs of hired workers	16.45	€ hour^{-1}
PRICEspray	:	Contract work price of spraying	31	€ ha^{-1}
PRICEplough	:	Contract work price of ploughing	137	€ ha^{-1}
PRICEfrezen	:	Contract work price of frezen	93	€ ha^{-1}
PRICErotor level	:	Contract work price of rotor levelling	48	€ ha^{-1}
PRICEsow	:	Contract work price of sowing	95	€ ha^{-1}
PRICEccrop	:	Contract work price of sowing a catch crop	76	€ ha^{-1}
PRICEmow	:	Contract work price of mowing	24	€ ha^{-1}
PRICEgrassharv	:	Contract work price of harvesting grass silage	70	€ ha^{-1}
PRICEride	:	Contract work price of riding silage stacks	44	€ ha^{-1}
PRICEgrcarry	:	Contract work price of carrying of grassland	7	€ ha^{-1}
PRICElevel	:	Contract work price of levelling maize land	48	€ ha^{-1}
PRICEcultiv	:	Contract work price of cultivate maize land	62	€ ha^{-1}
PRICEharrow	:	Contract work price of harrowing maize land	18	€ ha^{-1}
PRICEhoel	:	Contract work price of hoeing maize land	51	€ ha^{-1}

PRICEmaizeharv	:	Contract work price of harvesting maize silage	385	€ ha^{-1}
PRICEsodappl	:	Contract work price of applying manure by sod application	3.0	€ m^{-3}
PRICEsleep	:	Contract work price of applying manure by sleepvoeten	3.0	€ m^{-3}
PRICEinwerk	:	Contract work price of applying manure by inwerken	1.8	€ m^{-3}
PRICEinject	:	Contract work price of applying manure by injecterion	2.75	€ m^{-3}
PRICEmaint	:	Contract work price of maintaince of land	25	€ ha^{-1}
PRICEfuel	:	Price of fuel	0.98	€ kg^{-1}
PRICEimmov	:	Price of tax of immovable's (per 2268 €)	9.94	€ $taxunit^{-1}$
PRICEpwground	:	Price of polder and water tax of ground	33	€ ha^{-1}
PRICEpwbuild	:	Price of polder and water tax of buildings (per 2268 €)	0.3	€ $taxunit^{-1}$
PRICEintmaize	:	Price of interest of the maize	12	€ ha^{-1}
PRICEstorfloor	:	Price of floor of storage of roughage	35	€ m^{-2}
PRICEsilowall	:	Price of wall of silo for storage of roughage	120	€ m^{-2}
PRICEstmach	:	Price of investments of storage of machines	110	€ m^{-2}
PRICEgarage	:	Price of investments of garage	150	€ m^{-2}
PRICEststraw	:	Price of investments of storage of straw	100	€ m^{-2}
PRICEroad	:	Price of investment of field road	90	€ m^{-1}
PRICElpavath	:	Price of investment of pave path	40	€ m^{-2}
PRICEdrain	:	Price of a drain	0.162	€ m^{-2}