RUMEN8
DAIRY CATTLE RATION FORMULATION SOFTWARE

PILOTING APPROACH IN SUB-SAHARA AFRICA: A CASE OF KENYA

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SNV Netherlands Development Organisation
Connecting People's Capacities

PUM Netherlands senior experts

ProDairy

PERFOMETER DAILY GROWING DAIRY

ACKNOWLEDGEMENTS

The SNV KENYA/KMDP Rumen8 Team consists of Mr. Jos Creemers (Senior Dairy Sector Consultant, ProDairy E.A. Ltd), Mrs. Angela Gitau, Mr. James Kariuki and Mr. Patrick Ndungu (Perfometer Agribusiness Ltd), Ms. Frida Njoki (SNV Kenya/KMDP junior consultant and MSc graduate, Egerton University), Mr. Emmanuel Ewaju (SNV Kenya/KMDP intern and MSc student, Egerton University), Mr. Jackson Muchiri (SNV Kenya/KMDP junior consultant and MSc graduate, University of Nairobi), Mr. Pierre Poublan and Ms Dagmar Braamhaar (SNV Kenya/KMDP interns and MSc students, Wageningen University).
The team also includes Mr. Julius Kosgei and Mr. Matt Agesa (Junior dairy sector consultants) of SNV Kenya/KMDP, Eldoret and Mr. Paul Mambo (Team leader) and Mr. John Fredrick Ochido (Junior dairy sector consultant) of SNV Kenya/KMDP, Meru.

The team is supported by Dr. Hink Perdok (Senior expert, PUM, Netherlands) who has a long international career in animal nutrition, and by the Australian Rumen8 developers Dr. Martin Staines and Richard Morris.

Others supporting the team include Mr. David Maina (Managing Director, Perfometer Agribusiness Ltd), Mr. Tijs van Balen (Business development and marketing advisor at SNV Kenya/KMDP), Mr. Joseph Kipkoech Langat (Senior dairy vocational skills advisor at SNV Kenya/KMDP, Eldoret) and Mr. Anton Jansen (Program manager, SNV Kenya/ KMDP).

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LIST OF ABBREVIATIONS AND ACRONYMS

KMDP	Kenya Market-led Dairy Programme
PUM	Netherlands senior experts
R8	Rumen8 software
SNV	SNV Netherlands Development Organization
SSA	Sub-Sahara African countries
MAFC	Margin Above Feed Cost

EXECUTIVE SUMMARY

Rumen8 is a ration formulation software developed in New Zealand and Western Australia (WA). Initially it was developed by Dr. Martin Staines as a teaching aid at Lincoln University in New Zealand. When Staines moved to the Vasse Research Station in WA, it was adapted by him and Richard Morris to increase milk production and reduce feeding costs of dairy cows and heifers. SNV Netherlands Development Organization (SNV) in Kenya under the Kenya Market-led Dairy Programme (KMDP) collaborated with the developers of the software with the assistance of Dr. Hink Perdok of Netherlands Senior Experts (PUM) to introduce it in Sub-Sahara Africa. The collaboration started in early 2018 and continued till the closing of KMDP on 31 August 2019. Further adaptations of Rumen8 to tropical conditions were implemented in September and October 2019. Version 3.4.1.1 is the one in use in October 2019.

The first step in making the software suitable for Sub-Sahara Africa was to make a feed library having common feedstuffs found on dairy farms in Sub-Sahara Africa. (Initially while developing the feed library the feedstuffs were give the extension KENYA in the final version of the feed library which is now available on https://cowsoko.com/rumen8 this extension was removed) The software was then piloted on farms that were supported under various programmes by SNV Kenya/ KMDP and other collaborating institutions such as Perfometer Agribusiness Ltd and Bio Foods Ltd.

The software and the recommendations that followed by using the software were adopted well by the farmers. They appreciated it's impact on improving milk production and reducing feeds costs, consequently increasing margins above feed costs. If the recommendations were implemented it also helped to improve the body condition. The experiences of the team piloting the software were shared with the developers of the software to further improve it.

The main challenge faced when piloting Rumen8 was the accuracy of the data received at the farm. Initially, most of the farms did not accurately measure the feeds given to the cows. Moreover, they often overestimated the milk yields of the cows. This led to inaccurate representation of the actual current situation on the farms. However, with the guidance of the team involved in piloting the software, the farms gradually began to see the need to accurately measure the feeds and milk production. This was reflected in the ease of use of the software in subsequent farm visits.

CHAPTER 1. INTRODUCTION

Starting early 2018, SNV KENYA/ KMDP has introduced and piloted in Kenya a total diet rationing software for dairy cows from Australia named Rumen8. It emerged as the best choice among several ration formulation software packages because of its user friendliness, it is in the English language and it generates nutritional and monetary advice. It is based on sound nutritional principles and equations and has the possibility to modify equations according to Sub-Sahara Africa conditions, for example, to give more realistic estimates of dry matter intake. The software came with a comprehensive and relevant feed library with the possibility to expand it with feeds found in Kenya and Sub-Sahara Africa, including their prices. In addition, the software can be downloaded for free along with a user guide and there are tutorials on You Tube for further guidance. It is also actively supported by a helpdesk and frequent updates from the developers of the software in Australia.

To make the software useful for Kenya and other Sub-Sahara African countries, a Sub-Sahara Feed Library was composed from data from reliable sources and adjustments were made according to the needs of the Sub-Sahara Africa dairy farmers. The basis of this SSA feed library are forages grown under tropical climatic conditions and industrial by-products. apart from an initial start with the identification of some sources (Feedipedia etc) the Developers were not involved in the population of the SSA Feed Library. That massive work was done by the Kenyan R8 team.

The tool assists dairy advisors (consultants and extension workers) to advise the farmer as regards making an optimal ration for dairy cows, taking into account (amongst other factors) the breed/weight of the cow, the farming system under which the cow is kept, the expected/targeted milk production, the milk composition, the ingredients (weight and price) of the ration (including forages), and the milk price in the currency of the relevant country. The tool helps in optimizing the margin above feed costs (MAFC) and the productivity of the cow, hence it seeks to sustainably increase the economic performance of the dairy enterprise.

Between March 2018 and June 2019, the software has been tested or applied in 30 medium and large scale dairy farms in Kenya (for details see Appendix 2). These farms were selected due to their participation in previous SNV KENYA/ KMDP projects or were clients of Perfometer Agribusiness Ltd (an agribusiness consultancy company) or Biofoods Ltd (a milk processing company). The SNV KENYA/ KMDP Rumen8 Project Team continued using/further deployed the tool for farm advisory and impact measurement during the period January- May 2019. The focus was on medium and large scale farms with monthly repeat visits/advisory and impact measurement of the optimized rations as regards feeding costs, productivity of the lactating herd, cow conditions, and margins above feed costs. The final R8 Feed Library was delivered in August 2019, and made publicly available on the SNV- Cowsoko website. The link to the feed library is: https://cowsoko.com/kmdp/rumen8

CHAPTER 2. RUMEN8 FEED LIBRARY FOR SUB-SAHARA AFRICA

2.1 The value of the Sub-Sahara Africa feed library

Rumen8 software can be downloaded for free https://www.rumen8.com.au/download/index.html and comes with an Australian feed library after the user has registered himself with the developers. This feed library is not suitable in Sub-Sahara Africa because of the higher levels of Neutral Detergent Fiber (NDF) in forages that grow in a tropical climate. NDF is used to estimate the feed intake of dairy cattle in the tropics because fiber in the feeds determines how much an animal can eat of these feeds. In addition, many of the feeds in the library are unique to Sub-Sahara Africa and therefore missing in the Australian library. This made the development of the Sub-Sahara Africa library vital for the uptake of Rumen8 in the region.

2.2 Development of the Sub-Sahara Africa feed library

The Embassy of the Kingdom of the Netherlands in Kenya sponsored the Kenya Market Led Development Program of The Netherlands Development Organization (SNV) in Kenya. Under this program the feed library was developed. The steps followed in the development of the Sub-Sahara Africa (SSA) feed library were:

i. Data collection from trusted/reliable sources
ii. Data entry into spreadsheets
iii. Data transfer from spreadsheets into Rumen8

2.2.1 *Data collection from secondary sources*

The following sources of secondary data were used to make Rumen8 useful for Kenya amongst other SSA countries:

i. Ministry of Agriculture, Fisheries and Livestock (MoALF) database
ii. CGIAR/ International Livestock Research Institute (ILRI) Sub-Sahara Feed Composition database
iii. Association of Kenya Feed Manufacturers (AKEFEMA) concentrates database for monogastrics
iv. Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) database
v. BLGG (now Eurofins)
vi. CVB (Dutch Database)
vii. Feedipedia (FAO Database)
viii. Feedplus (Australian Database)
ix. AFRC (United Kingdom Database)
x. Rumen8 Australian database
xi. PTC

The table below shows feed parameters used in Rumen8 that were collected for the various ingredients to make the Sub-Sahara Africa Library.

Table 2.1: Feed parameters used in Rumen8

Parameter	**Unit**
Dry matter (DM)	g/kg
Metabolizable Energy (ME)	MJ/kg DM
Crude Protein (CP)	g/kg DM
Ether Extract (EE or Fat)	g/kg DM
Calcium (Ca)	g/kg DM
Phosphorous (P)	g/kg DM
Magnesium (Mg)	g/kg DM
Potassium (K)	g/kg DM
Sodium (Na)	g/kg DM
Chlorine (Cl)	g/kg DM
Sulphur (S)	g/kg DM
DCAD	mEq/kg DM
aN	Fraction
bN	Fraction
cN	Fraction/h
ADIN	g/kg DM
Ca absorption	Fraction
P absorption	Fraction
Mg absorption	Fraction
Maximum feeding rate	g/kg diet DM
NDF	g/kg DM
eNDF in NDF	g/kg DM
Starch	g/kg DM
Sugar	g/kg DM
Ash	g/kg DM
Cost/tonne fresh in KES	KES

2.2.2 *Data entry into spreadsheets*

Three spreadsheets were used to collect and sort data collected. These were the Forage , Concentrate and Mineral supplements spreadsheets.

2.2.2.1 Roughage spreadsheet

The Rumen8 data on forages highlighted in grey color in Table 2.2 below were tentative data that were only used for comparison purposes and were not included in the calculated average values highlighted in green at the bottom of the table. After data entry, the feed was initially given the extension 'KENYA DRAFT' until approved by the Rumen8 team. It was then renamed and given the extension 'KENYA' as shown in Table 2.2 with a red arrow. The same procedure was followed when filling the concentrate and minerals supplement spreadsheets. The extension 'KENYA' was removed in the Sub-Sahara Africa feed library.

Table 2.2: Roughage spreadsheet

			Fat or														Ca absorption	P absorption	Mg absorpion	Max.						
Lucerne fresh KENYA	**DM**	**ME**	**CP**	**EE**	**Ca**	**P**	**Mg**	**K**	**Na**	**Cl**	**S**	**DCAD**	**aN**	**bN**	**cN**	**ADIN**	0.60 concentr.	0.70 concentr.	0.16 concentr.	feeding	**NDF**	**eNDF**	**Starch**	**Sugar**	**Ash**	**Cost/ t**
Source of information / Rumen8 parameter	**g/kg**	**MJ/kg DM**	**g/kg DM**									mEq/kg DM	**fraction**	**fraction**	**fraction**	g/kg DM	0.30 roughage	0.64 roughage	0.16 roughage	rate	**g/kg DM**					**fresh in KES**
Rumen8 (DM) KENYA DRAFT, comparison only	219	9.4	199	28	13.2	2.9	2.8	27.0	1.45	4.2	3.0	450	0.34	0.58	0.12	1.3	0.30	0.64	0.16		406	697	48	92	97	
Animal Nutrition (7th Edition)-[Average#3]	250		171	17	22.0	3.0	3.0				2.0										442				100	
ASARECA (2013): Fresh vegetative (TZ, Ke, Rw) pg 59	250	7.5	184	14	15.0	3.0											0.3	0.64	0.16		467				96	
Feedipedia	199	9.4	206	29	19.4	2.5	2.8	22.4	0.5				0.441	0.466	0.169		0.3	0.64	0.16		393		3		115	
FEEDPLUS [average# 25]	251	10.8	263	34	14.7	3.7	4.4	18.1	2.7	13.0	2.9						0.3	0.64	0.16		316		25	36	94	
MOAFL (Kariuki,1998; Mbugua and Gachuiri, 2004)	300	8.0	194		14.0	2.4											0.3	0.64	0.16							
PDTC - [average #5]	220	9.2	184	30	13.5	2.7		26.0		4.0	2.9						0.3	0.64	0.16						90	
SSA Feed Comp. Database CGIAR/ILRI (Ethiopia#45)		9.2	198			2.65															383					
Estimate																1.2										
Feed price per 1000 kg *as is*																										3500
AFFC: ADIN & eNDF from eNDF guidelines																										
Average	245	9.0	200	25	16.4	2.8	3.4	22.2	1.62	8.5	2.6		0.441	0.466	0.169	1.2	0.30	0.64	0.16		400	697	14	36	99	3500
StDev	34	1.2	30	9	3.5	0.4	0.9	3.9	1.58	6.4	0.5						0.0	0.0	0.0		58		16		10	
CV	14%	13%	15%	35%	21%	15%	26%	18%	98%	75%	20%						0%	0%	0%		15%		111%		10%	
Count	6	6	7	5	6	7	3	3	2	2	3	0	1	1	1	1	5	5	5	0	5	0	2	1	5	1
After review, add the new feed to the Rumen8 feed library using the data in the green line and change the name of the feed from .... KENYA DRAFT into .... KENYA																										

2.2.2.2 Concentrates spreadsheet

Similar feed data parameters summarized in Table 2.2 were entered into the concentrate spreadsheet. The database sources were similar to those used to fill the forage spreadsheet except for CVB, 2016 database which is a Dutch feed database for concentrates, moist co-products and forages for ruminant and monogastric animals. Its values are on 'as is' basis and have to be converted to dry matter basis. The average parameter value calculated on the spreadsheet considers CVB values on dry matter basis only.

Table 2.3: Concentrates spreadsheet

1	Maize Grain KENYA				Fat or													Ca absorption	P absorption	Mg absorpior	Max.						Price or
2		DM	ME	CP	EE	Ca	P	Mg	K	Na	Cl	S	DCAD	aN	bN	cN	ADIN	1.60 concentr	0.70 concentr	0.16 concentr	feeding	NDF	eNDF	Starch	Sugar	Ash	Cost/ t
3	Source of information / Rumen8 parar	g/kg	MJ/kg DM	g/kg DM									mEq/kg DM	fraction	fraction	fraction	g/kg DM	0.30 roughage	0.64 roughage	0.16 roughage	rate	g/kg DM					fresh in KES
4	Rumen8 (DM) KENYA DRAFT, comparison only																											
5	Rumen8 (DM)	882	13.5	93	42	0.4	3.1	1.2	4.2	0.40	0.6	2.0	-18	0.190	0.770	0.040	0.4	0.60	0.70	0.16	300	107	485	725	20	16	
6	AKEFEMA (DM) maize (white)	933.2	13.9	80	77.8																						
7	AKEFEMA (DM) maize grain	865.7	14.1	70.3	50.6	0.2																					
8	ASARECA, 2013 (DM)	887		103	41.2	0.4	2.1																				
9	BLGG, 2013 (as is?; taken as DM)no data																										
10	CVB, 2016 (*as is*)	867	12.4	76	36	0.1	2.4	0.8	3.4	0.00	0.5	0.1										95		649	13	12	
11	CVB, 2016 (DM)	867	14.4	88	42	0.1	2.8	0.9	3.9		0.6	0.1										110		749	15	14	
12	Feedipedia (DM) Europe	863	13.6	94	43	0.5	3.0	1.2	3.9	0.00												122		734	21	14	
13	Feedipedia (DM) Subsahara and East Africa	900	13.6	80	45	0.4	2.9	0.5	3.6	0.50				0.097	0.635	0.050						155		733	17	43	
14	FeedPlus (Australia) (DM)																										
15	MoAFL Feedstuff database Kenya (DM	870	13.6	90		0.7	2.7																				
16	PTC - maize grain	900	14.0	100		0.3	2.9																	719	15		
17	PTC - maize (white)	900	16.1	106		-	4																	-	-		
18	SSA Feed Comp. Database CGIAR/ILRI	877	11.9	124		0.1	0.3			0.18																	
19	Feed price per 1000 kg *as is*																										30,000
20	ARFC: ADIN & eNDF from eNDF guidelines																										
21	Average	886	13.9	93	49	0.3	2.6	1.0	3.9	0.27	0.6	1.1	-18	0.144	0.703	0.045	0.4	0.60	0.70	0.16	300	123	485	732	18	22	30000
22	StDev	21	1.0	15	13	0.2	1.0	0.3	0.2	0.22	0.0	1.3		0.066	0.095	0.007						22		11	3	14	
23	CV	2%	8%	16%	27%	55%	39%	35%	6%	83%	3%	126%		46%	14%	16%						18%		2%	16%	66%	
24	Count	11	10	11	7	9	9	4	4	4	2	2	1	2	2	2	1	1	1	1	1	4	1	5	5	4	1

2.2.2.3 Mineral Supplements spreadsheet

The data was sourced from mineral supplement packaging from various veterinary shops in Nairobi city and Nakuru town. There are four mineral supplements spreadsheets and they contain data on mineral supplements for:

- High producing dairy cows
- Dairy cows
- Dry cows
- Calves and heifers

Table 2.4: Mineral supplements spreadsheet

Mineral Supplements for Dairy Cows KENYA DRAFT								Ca absorption	P absorption	Mg absorpion	Max.	Price or
	Ca	P	Mg	K	Na	Cl	S	0.60 concentr.	0.70 concentr.	0.16 concentr.	feeding	Cost/ t
Source of information / Rumen8 parameter	g/kg DM	g/kg DM	g/kg DM	g/kg DM	g/kg DM	g/kg DM	g/kg DM	0.30 roughage	0.64 roughage	0.16 roughage	rate	fresh in KES
Rumen8 (DM) KENYA DRAFT, comparison only												
Cattlemin	150.0	62.0	60.0		94.86	105.1		0.60	0.70	0.16	100 g	150000
Maclik Super	203.6	110.0	36.0		94.86	105.1		0.60	0.70	0.16	200 g	170000
Vitaphos Super Ultramax	204.0	87.0	7.5		142.30	157.7	2.5	0.60	0.70	0.16	150 g	240000
Twigalick Maziwa Zaidi	168.0	70.0	6.9		141.82	157.2		0.60	0.70	0.16	90g	150000
Supalick	153.0	115.0	30.0					0.60	0.70	0.16	210g	
Feed price per 1000 kg *as is*												
ARFC: ADIN & eNDF from eNDF guidelines												
Average	175.7	88.8	28.1		118.46	131.3	2.5	0.60	0.70	0.16		177500
StDev	26.5	23.5	22.1		27.25	30.2		0	0	0		42720
CV	15%	26%	79%		23%	23%		0%	0%	0%		24%
Count	5	5	5	0	4	4	1	5	5	5	0	4

2.2.3 Data transfer from spreadsheets into Rumen8

2.2.3.1 Feed parameter data transfer

The following procedure was followed when transfering data from the spreadsheets into Rumen8:

1. Rumen8 software was started up and 'Edit' clicked on in the task bar, then clicked on 'Edit Feeds' (red arrow in Figure 2.1 below).

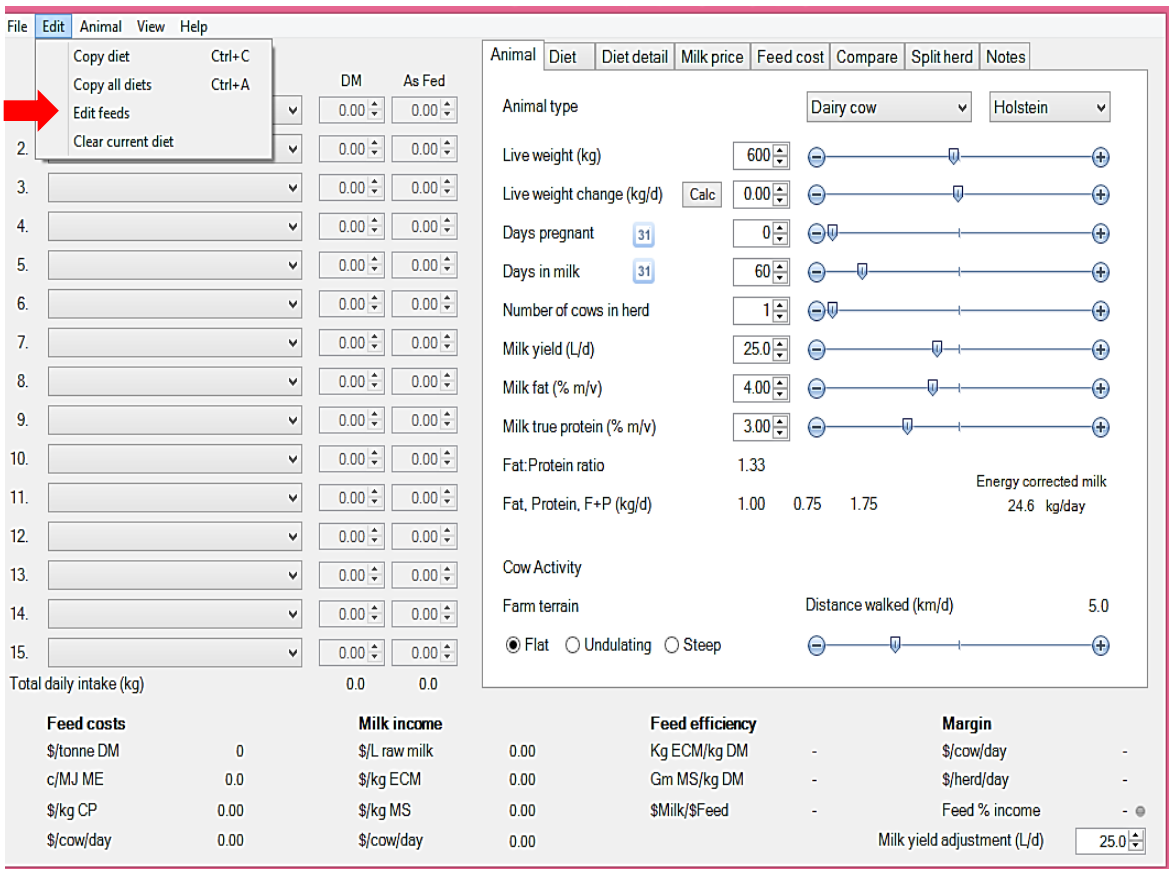


Figure 2.1: The 'Edit feeds' option in Rumen8

2. After clicking on ‘Edit Feeds’, a page showing names and categories of the feed in the library appeared then, ‘Edit feed parameters’ was clicked on as indicated by the red arrow in Figure 2.2 below.

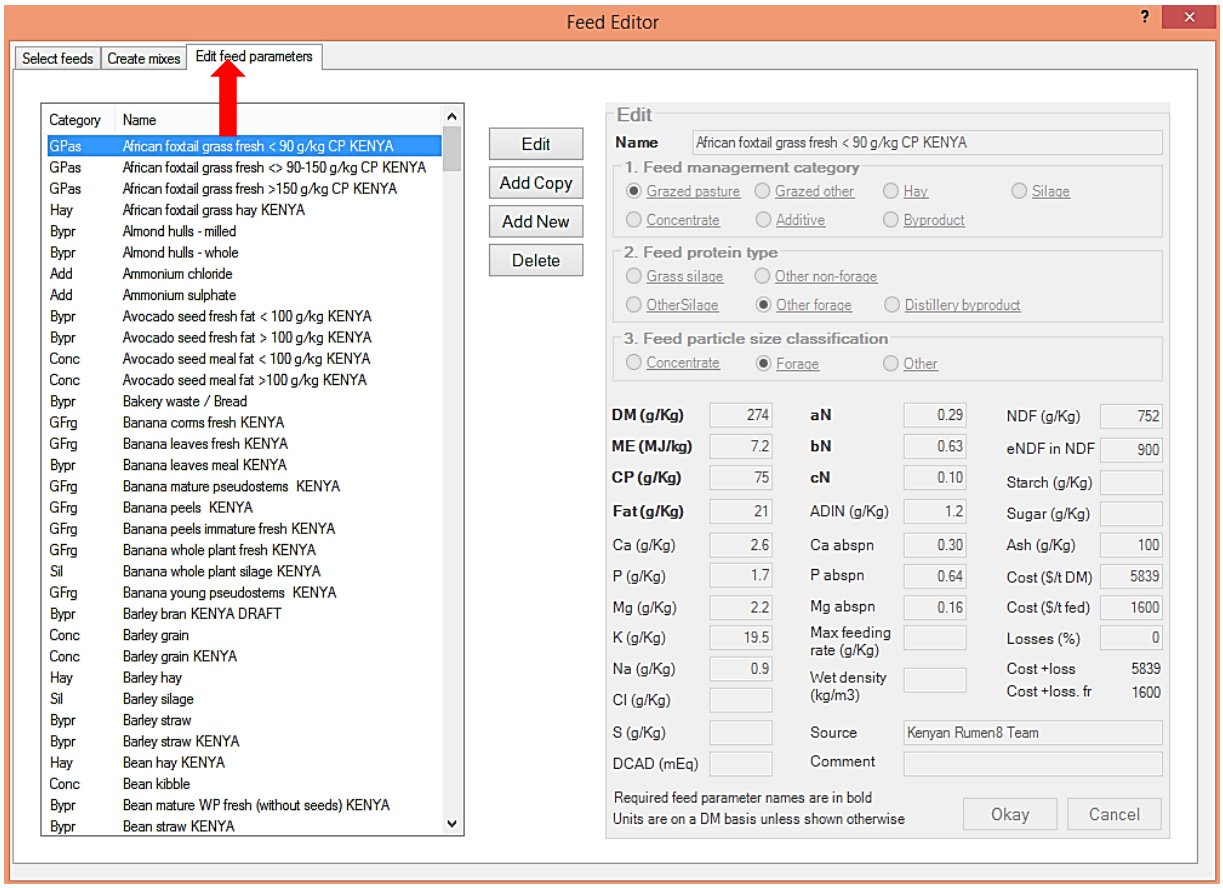


Figure 2.2: The 'Edit Feed parameters’ tab in Rumen8

3. Feed in the Australian library whose parameters were close or similar to those to be added to the library due to similar characteristics, species or variety was selected. Then 'Add copy' was selected (green arrow in Figure 2.3), it appeared as in figure 2.4. Name of the feed was edited to give it a new unique name e.g. from 'Barley grain (copy)' to 'Barley grain KENYA' and then other parameters were edited according to the data spreadsheet. 'Okay' was then clicked to save the feed. Always add a copy ('Add Copy') of a feed in the Australian library instead of adding a new ('Add New') feed as this may lead to wide variations or incorrect input of parameters recorded.

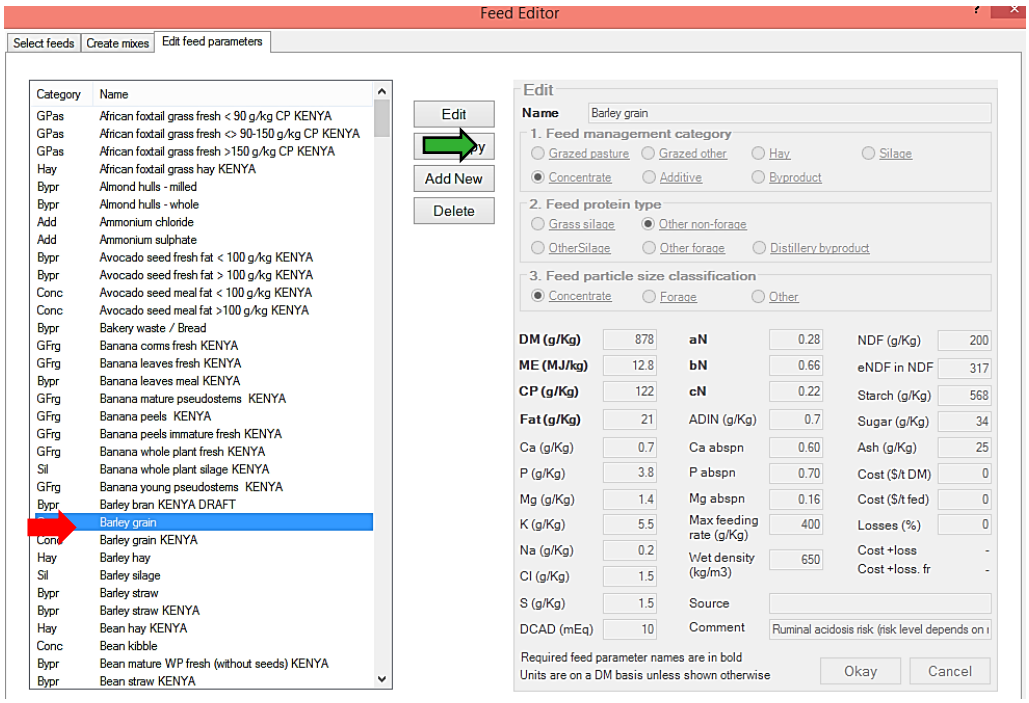


Figure 2.3: The 'Add copy' task bar on Rumen8

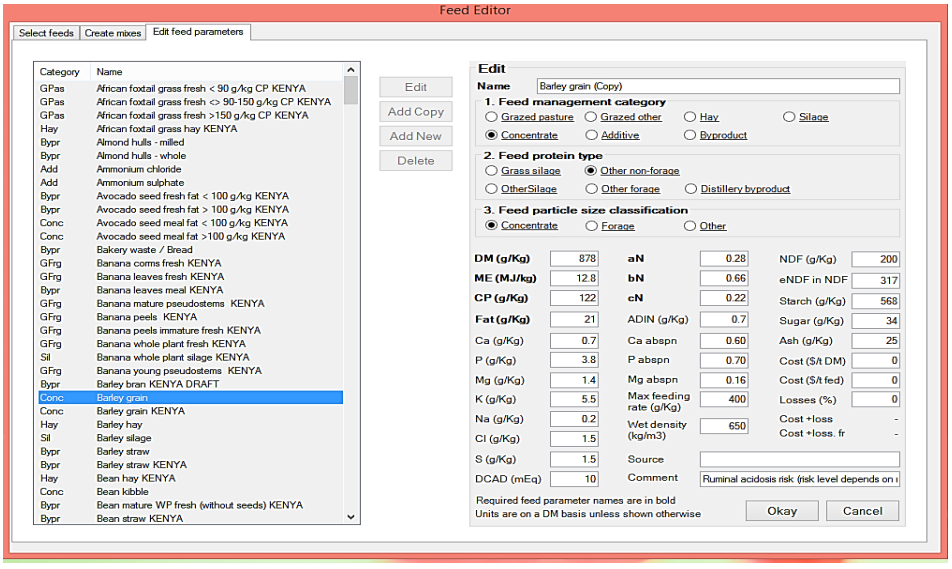
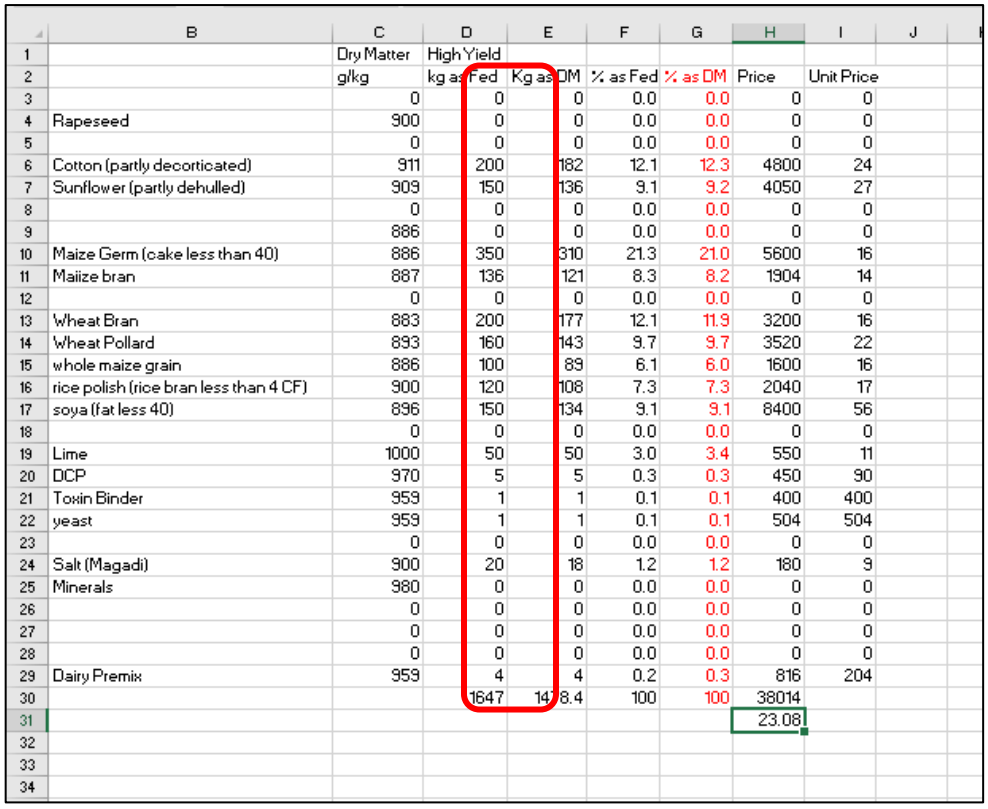


Figure 2.4: Adding a copy of feed in the feed library in Rumen8

2.2.3.2 Creating feed mixes using Rumen8

After visiting several farms, it was observed that some farmers made their own feed mixes using their own ingredients. Therefore, these mixes were incorporated in the Rumen8 library through the following procedure.

1. Excel spreadsheet was filled (made and used next to Rumen8) in the 'Kg as fed' column (red out-line in Figure 2.5). The Rumen8 team inserted formulas in this spreadsheet so that it calculates the % dry matter of the feed ingredients (red text in Figure 2.5) and the cost per kg of the feed mix on 'as fed' basis (green outline in Figure 2.5). These are the values to be inputed in Rumen8.



	B	C	D	E	F	G	H	I	J
1		Dry Matter	High Yield						
2		g/kg	kg as Fed	Kg as DM	% as Fed	% as DM	Price	Unit Price	
3		0	0	0	0.0	0.0	0	0	
4	Rapeseed	900	0	0	0.0	0.0	0	0	
5		0	0	0	0.0	0.0	0	0	
6	Cotton (partly decorticated)	911	200	182	12.1	12.3	4800	24	
7	Sunflower (partly dehulled)	909	150	136	9.1	9.2	4050	27	
8		0	0	0	0.0	0.0	0	0	
9		886	0	0	0.0	0.0	0	0	
10	Maize Germ (cake less than 40)	886	350	310	21.3	21.0	5600	16	
11	Maiize bran	887	136	121	8.3	8.2	1904	14	
12		0	0	0	0.0	0.0	0	0	
13	Wheat Bran	883	200	177	12.1	11.9	3200	16	
14	Wheat Pollard	893	160	143	9.7	9.7	3520	22	
15	whole maize grain	886	100	89	6.1	6.0	1600	16	
16	rice polish (rice bran less than 4 CF)	900	120	108	7.3	7.3	2040	17	
17	soya (fat less 40)	896	150	134	9.1	9.1	8400	56	
18		0	0	0	0.0	0.0	0	0	
19	Lime	1000	50	50	3.0	3.4	550	11	
20	DCP	970	5	5	0.3	0.3	450	90	
21	Toxin Binder	959	1	1	0.1	0.1	400	400	
22	yeast	959	1	1	0.1	0.1	504	504	
23		0	0	0	0.0	0.0	0	0	
24	Salt (Magadi)	900	20	18	1.2	1.2	180	9	
25	Minerals	980	0	0	0.0	0.0	0	0	
26		0	0	0	0.0	0.0	0	0	
27		0	0	0	0.0	0.0	0	0	
28		0	0	0	0.0	0.0	0	0	
29	Dairy Premix	959	4	4	0.2	0.3	816	204	
30			1647	1478.4	100	100	38014		
31							23.08		
32									
33									
34									

Figure 2.5: The 'Kg as fed' column in the Excel Dairy meal spreadsheet

2. Rumen8 software was started up and 'Edit' clicked on the task bar. 'Edit Feeds' was selected and a page appeared showing the names and categories of the feed in the library. 'Create mixes' was selected, as indicated (red arrow) in Figure 2.6.

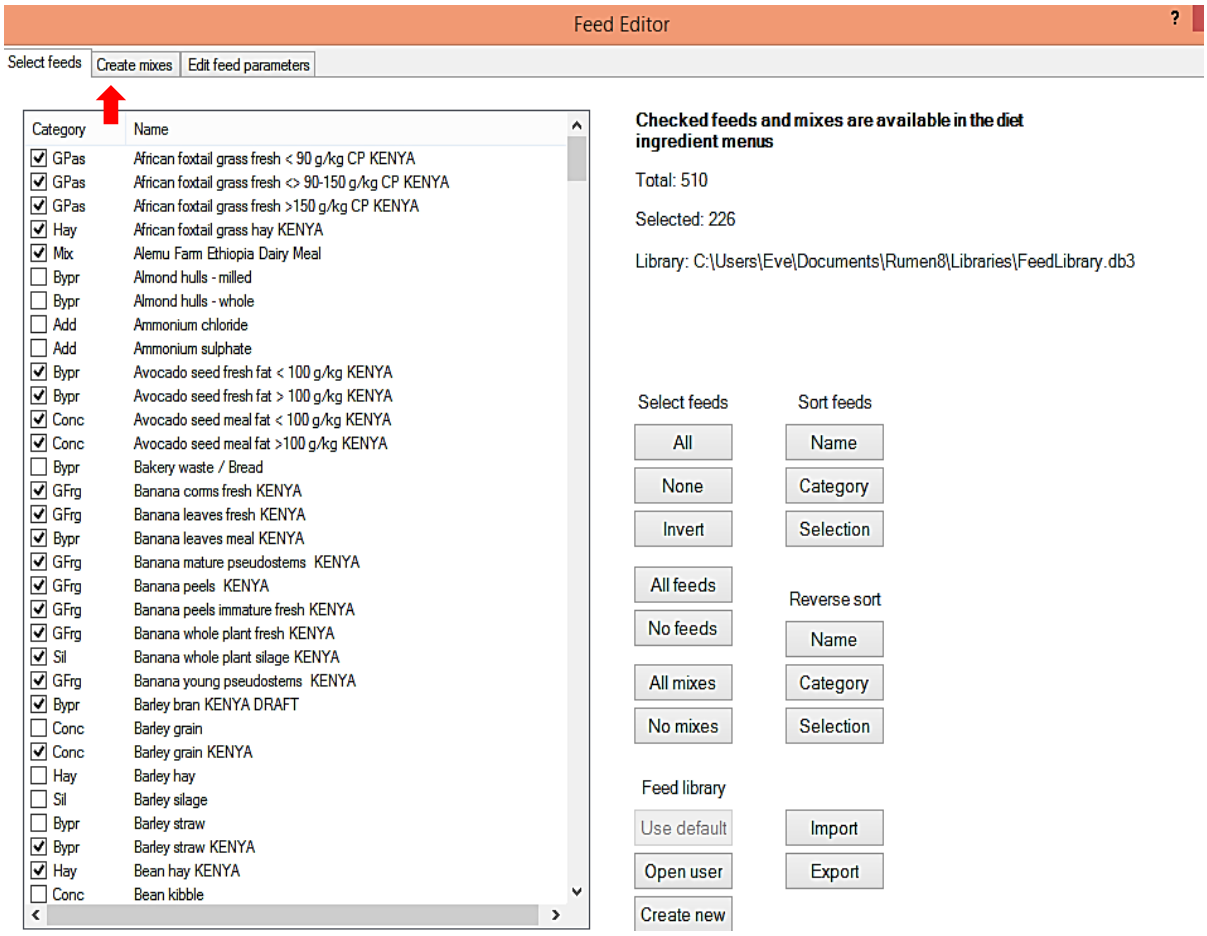


Figure 2.6: The 'Create mixes' task bar in Rumen8

3. ‘Add New’ was selected to create a new feed mix for the farm. On the ‘Edit’ section, feeds available at the farm were added using the Rumen8 library. The percentage Dry Matter (DM) were added from the Excel 'Dairy meal' datasheet (Figure 2.5). The total was ensured to be 100%. Name of the mix and its cost on ‘kg as fed’ basis were added as shown in figure 2.7 below. The source of the information and a comment on the mix were added and then ‘Okay’ clicked to save it in the library.

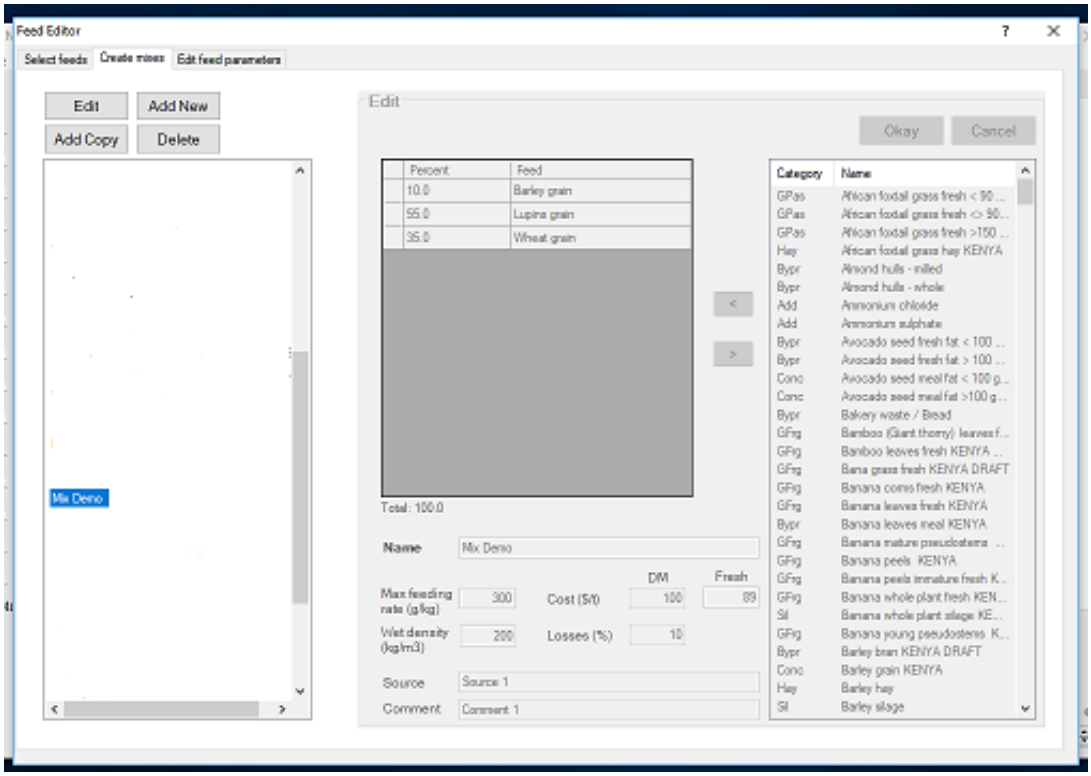


Figure 2.7: Creating mixes in Rumen8

4. There were cases where a farm had different mixes for different groups of animals (as shown in figure 2.7 using a red arrow). To create mixes for the other groups of animals, an existing feed mix of the farm was selected and then 'Add Copy'. It appeared as in figure 2.8 below. The name of the mix was edited. Feeds and their percentage inclusion in the mix in accordance to the nutritional demand of the group were edited. Then the cost of the feed on 'As fresh' basis keyed in and 'Okay' clicked on to add the mix to the feed library.

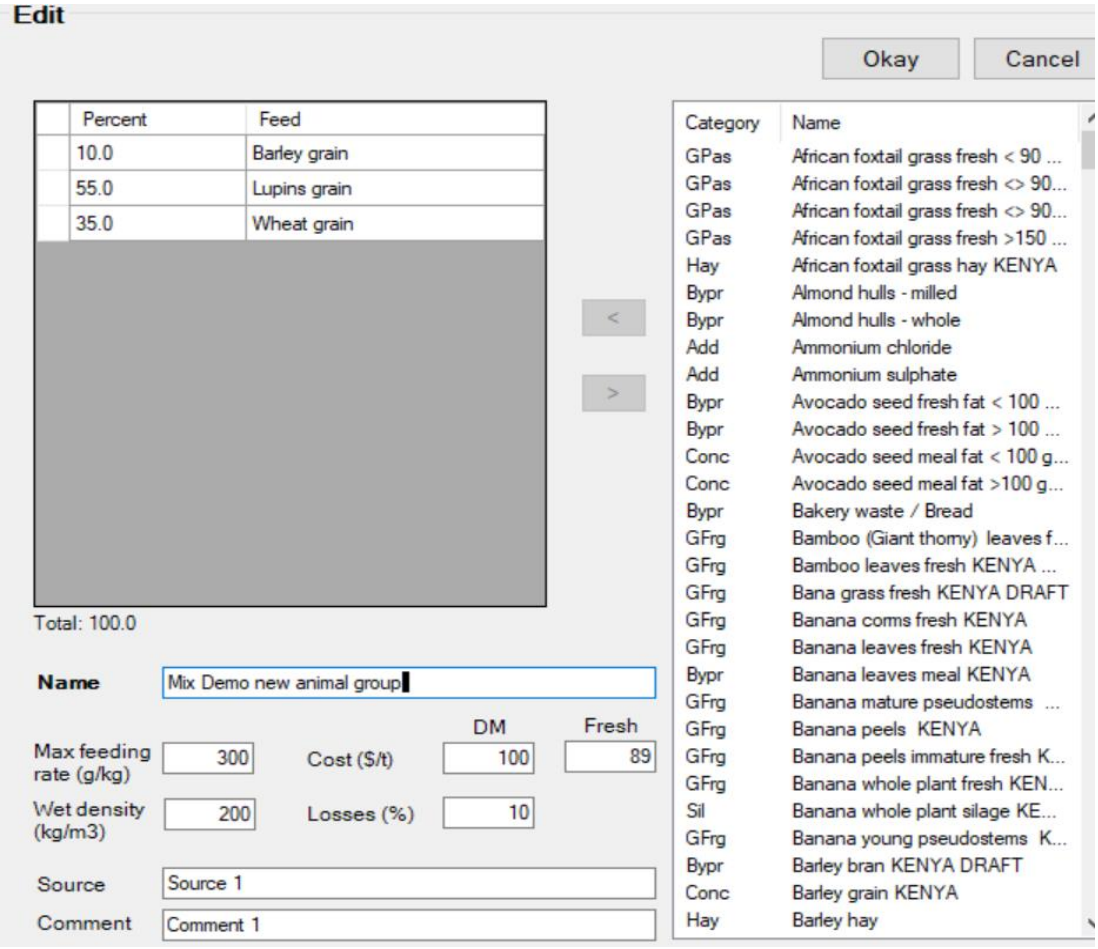


Figure 2.8: Creating new mixes in Rumen8

2.3 Reliability of the Sub-Sahara Africa feed library

This feed library was developed using book values borrowed from several databases. These values can easily be replaced with the more accurate laboratory analysis of feeds present at the individual farms. However in the absence of such laboratory analysis, using this feed library with book values is the next best alternative.

2.4 Intended use and users of the Sub-Sahara Africa feed library

This library can only be used as a guide when making balanced rations for dairy cattle. It cannot replace good feeding management of the cows. In addition, the targeted animals are the best indicators of the suitability of the recommended diets and the response of the animals can be used to further adjust the diet.

The users of this library are animal nutritionists in Sub-Sahara Africa. Several neighbouring countries share the same climatic conditions as Kenya and therefore the feeds, especially forages, have similar levels of NDF, which is the driver of feed intake by cows in this region.

CHAPTER 3. PILOTING RUMEN8 ON KENYAN FARMS

3.1 Farm selection

3.1.1 Farm relevance

Medium Scale Farms (MSFs) and Large Scale Farms (LSFs) were selected on the basis of inputs availability and business linkages. Inputs availability is the willingness of the farm to change and improve feed management/diet according to the recommendations delivered by the Rumen8 team. Business linkages are the farms that have existing dairy support services from SNV, like Perfometer Agribusiness and Biofoods that facilitate data collection and offer guarantee of commitment.

3.1.2 Farm characterization

The MSFs have been defined for the purpose of the present studies as the farms producing milk between 100 liters/day and 600 liters/day. Hence the LSFs are the farms producing more than 600 liters of milk/day.

3.1.3 Farm dispersion

For logistics purposes, the farm sample was divided into 3 clusters on the basis of geographical location. Each cluster was assigned to a team, responsible for follow-up and visits as shown below:

- Central Kenya region: Perfometer Agribusiness/SNV Nairobi
- North Rift region: SNV Eldoret
- Meru region: SNV Meru

Farmers in the Central Kenya region were selected from the client base of Perfometer Agribusiness, those in the North Rift region some were selected by Biofoods due to the business linkage with SNV/KMDP while others had participated in the maize train SNV/ KMDP intervention and those in the Meru region had taken part in previous SNV/KMDP projects.

3.2 Farm visits

Preliminary farm visits coincided with the development of the SSA Rumen8 feed library in March 2018 so that the team could identify both common and unique feeds available on Kenyan farms and get practical ration formulation experience. Once the Sub-Sahara Africa feed library was complete, a memorandum of understanding was signed between the farmers, SNV Kenya/KMDP, Perfometer Agribusiness and Bio Foods (Appendix 1).

A farm visit protocol was developed (Appendix 3) and it aimed to capture the feeding regime and general herd data. More comprehensive farm visits started in July 2018 followed by weekly phone calls to evaluate the progress and monthly return visits to change or improve the recommendations. A higher frequency of return visits was tried and had positive results on the implementation of the recommendations but logistics, time and resource constraints prevented this.

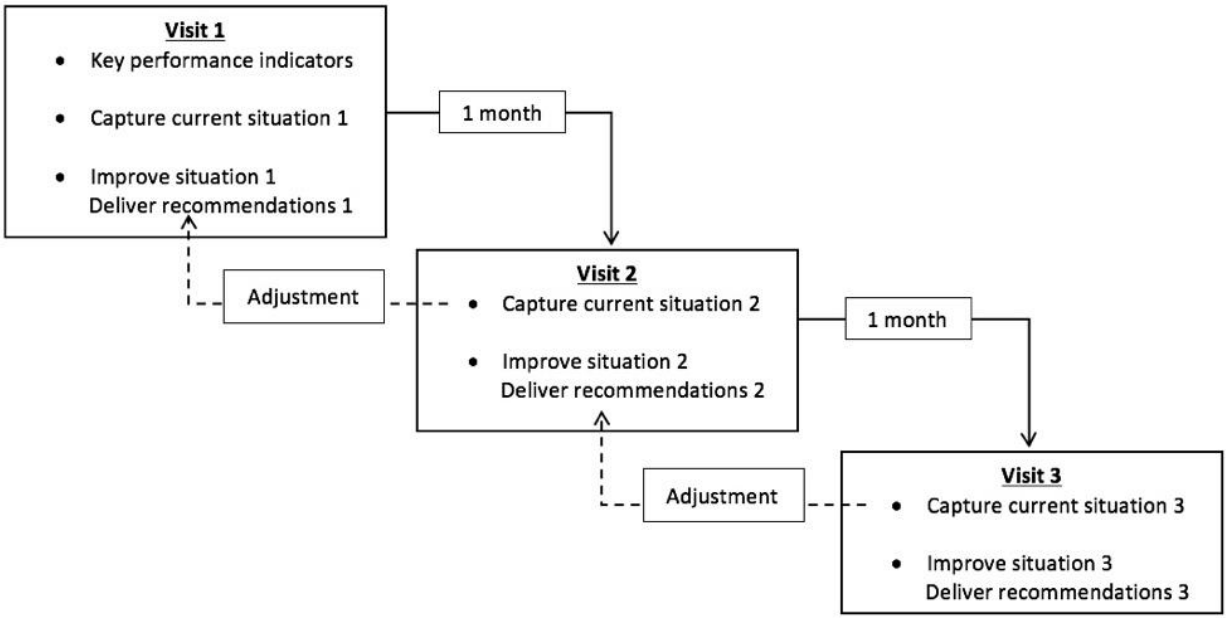


Figure 3.1: Summary of evaluation process of farms receiving Rumen8 advice

Critical assessment during the visit was vital for an effective use of Rumen8 (R8). Consequently, amount of feed given, milk produced, and cost generated were recorded in the most accurate way possible. Practically, the current situation observed and recorded in Rumen8 was adjusted if the outputs were not in accordance with the model and the observations. The objective was to have a match between Rumen8 and the current situation.

During the first visit, an improved diet was formulated with the help of R8 for early and mid-lactation groups of cows. The recommended diet systematically aimed at (see Figure 3.2):

- Balancing the current diet in terms of nutrients and voluntary intake (Figure 3.3)
- Fulfilling the cow's requirements in terms of nutrients and dry matter intake
- Sustaining or increasing the milk production
- Increasing the Margin Above Feed Costs (MAFC)
- Including feedstuffs available in a sustainable way

The recommendations were discussed with the farmer or farm manager for approval and delivered at the end of the visit in hard copy (Appendix 2) and a soft copy was sent via email. These recommendations were as realistic as possible and followed a step by step approach of improving the cows' diets up to the optimal level.

During the subsequent visits, the new feeding regime was recorded using the same approach. If improvements were required, the diets were reformulated and improved according to access to and availability of feeds and forages) on the farm. After three visits, the team evaluated the progress of the farm and their uptake of the new recommendations. If the farm was unable to follow the recommendations after three visits, the visits were discontinued until the farm was able to follow the Rumen8 team recommendations.

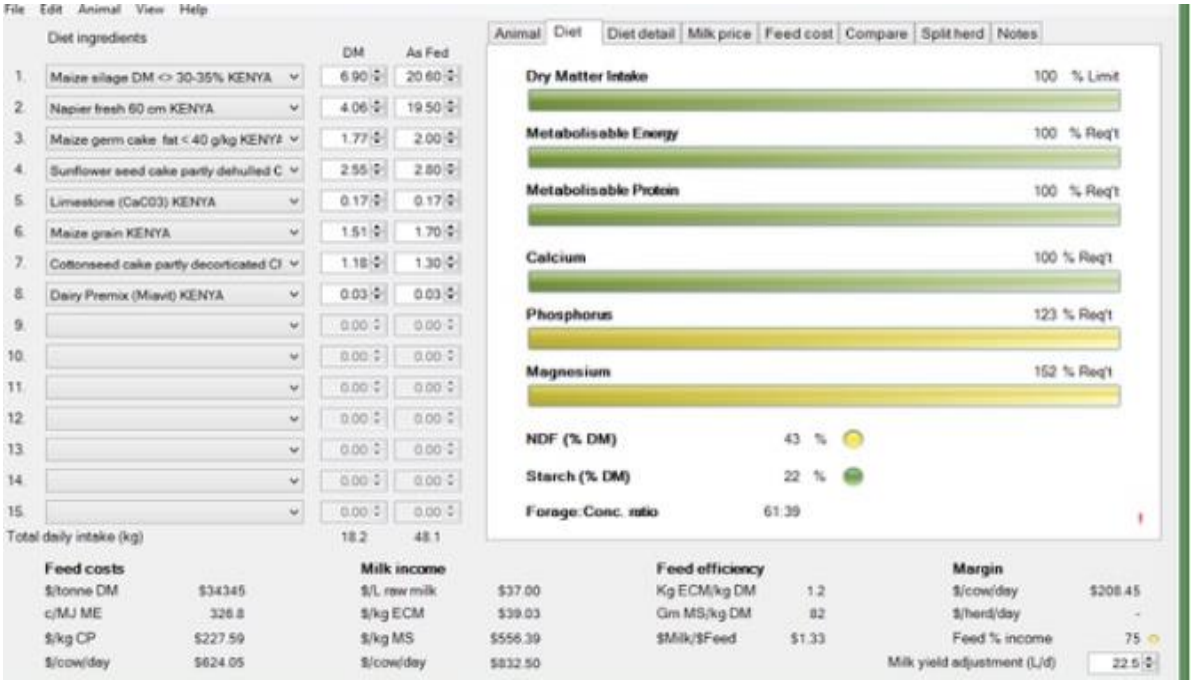


Figure 3.2: Example of a balanced diet in Rumen8

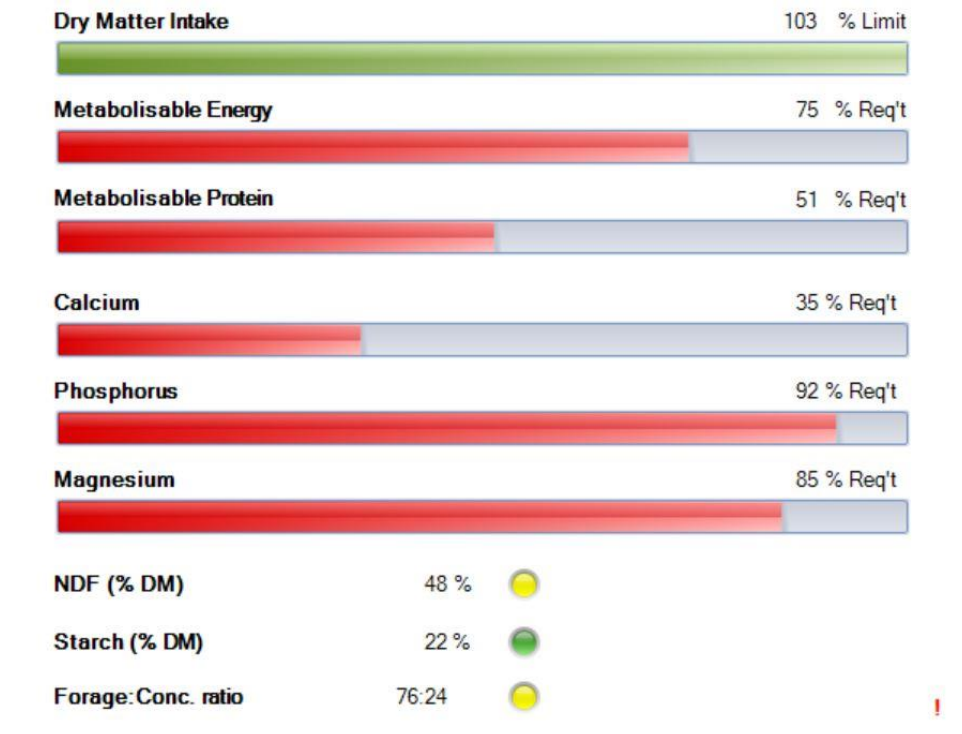


Figure 3.3: Example of an imbalanced diet

3.3 Animal parameters and diet ingredients used by Rumen8

3.3.1 Dry Matter Intake prediction

The Dry Matter Intake (DMI) was predicted as 1.3% of the cow's body weight as Neutral Detergent Fiber (NDF) in the feeds, which was shown to be more relevant (see Mertens et al, 1997) in Sub-Sahara Africa compared to the National Research Council (2001) as prediction for DMI. Both options are however available on Rumen8 (Figure 3.4).

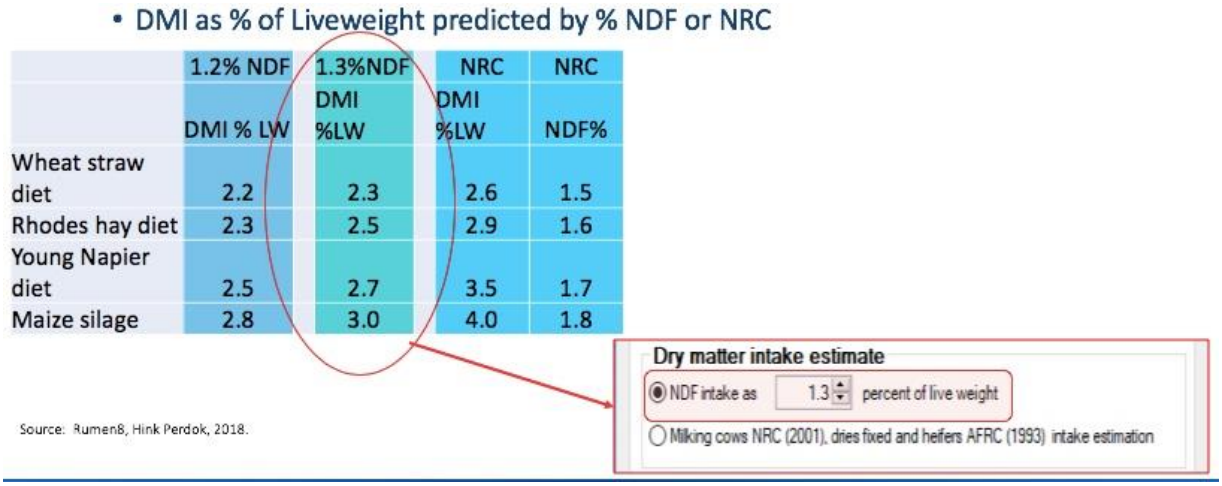


Figure 3.4: Identifying the suitable %NDF to use to estimate DMI

3.3.2 Preferences for required levels

The targeted nutrient level settings and the traffic light tolerance were adjusted according to the SSA situation and the animals under consideration. The objective was to be as accurate as possible. Example of preferences setting for targeted nutrient level can be found in Figure 3.5.

Figure 3.5: Preferences setting

3.3.3 Animal parameters

The total milk production during a lactation cycle and the current lactation phase of the cow were adjusted in order to have a guideline of the requirements of the cow (Figure 3.6).

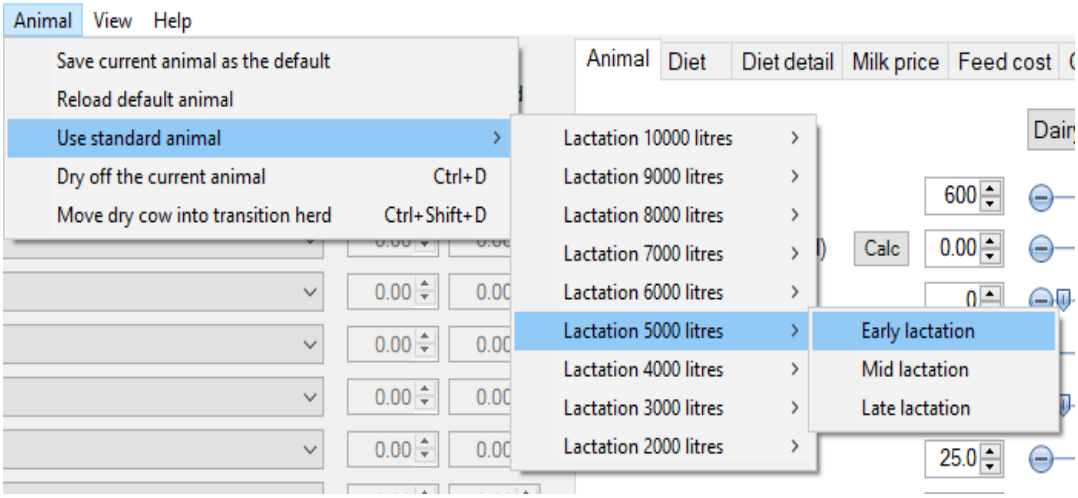


Figure 3.6: Lactation parameters

Other animal parameters include the breed, live weight (kg), live weight change (kg/d), days pregnant and days in milk. In the example below is an animal in early lactation and zero days pregnant (Figure 3.7).

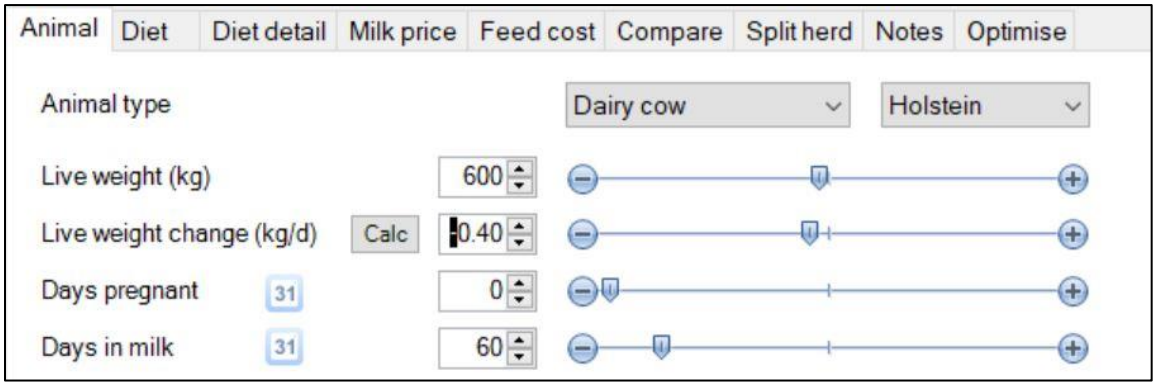


Figure 3.7: Animal parameters

The cow's daily activity is considered by Rumen8 and was adjusted by the Rumen8 team based on the actual situation in the farms, i.e the inclination of the terrain and the distance walked by the animals, as it affects the daily energy requirement (Figure 3.8). In stall-fed cows, distance walked is assumed to be zero, even though in reality cows will walk a certain distance.

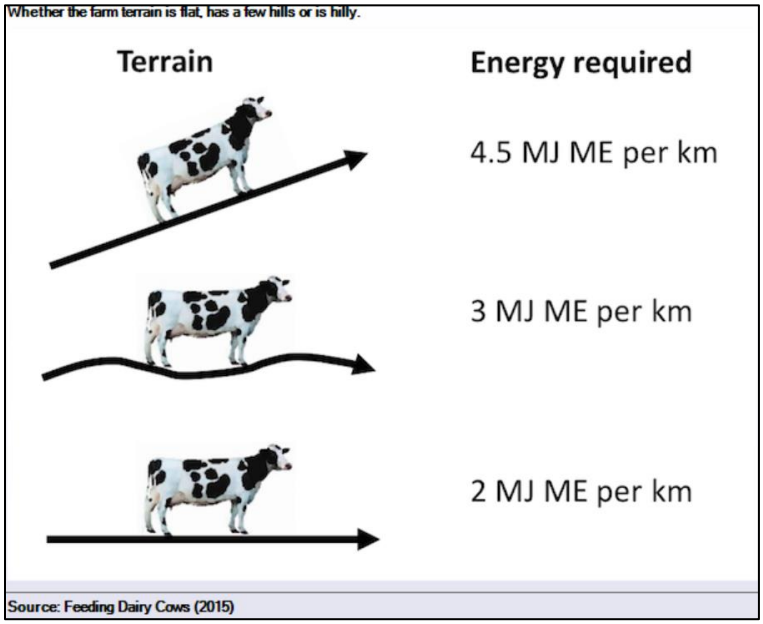


Figure 3.8: Cow's daily activity parameters

3.3.4 Milk parameters

The milk parameters considered in Rumen8 include the volume (kg or liters) and the composition (fat and protein content). As qualitative analysis of milk is generally lacking in Kenya, standard values of Milk Fat (3.65%) and Milk Protein (3.10%) for Holstein-Friesian cows was used (Source Kenya Livestock Breeders Organization). The price of the milk was also entered and expressed on

a Kenya Shilling (KES) per litre or kg basis. 12 different milk prices can be entered and, if need be, changed during each farm visit.

3.3.5 Feed parameters

The composition of the feeds used at the farm were estimated based on the SSA feed library (Fig 3.9) and observations on the feeds and forages. The diets considered were entered 'as fed' (kg) and directly computed on 'DM basis' by Rumen8 (Fig 3.10). The costs of the feeds were also entered in order to estimate the feed costs (Fig 3.11). Rumen8 then subtracted the diet cost from milk income to give the Margin Above Feed Cost (MAFC). Rumen8 also generates feed efficiency and feed cost as a percentage of the milk income.

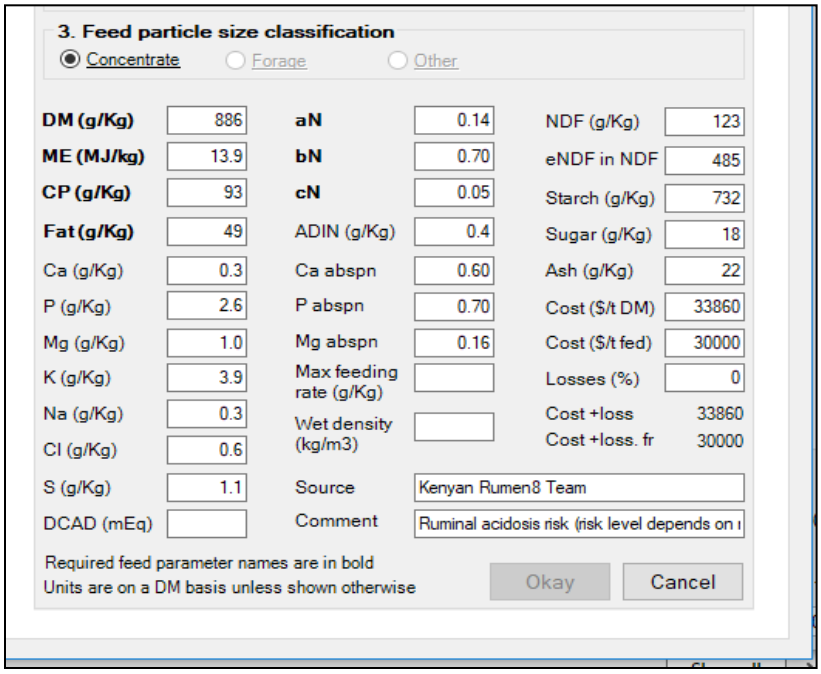


Figure 3.9: Example of a feedstuff composition in Rumen8

Figure 3.10: Dry matter computation by Rumen8

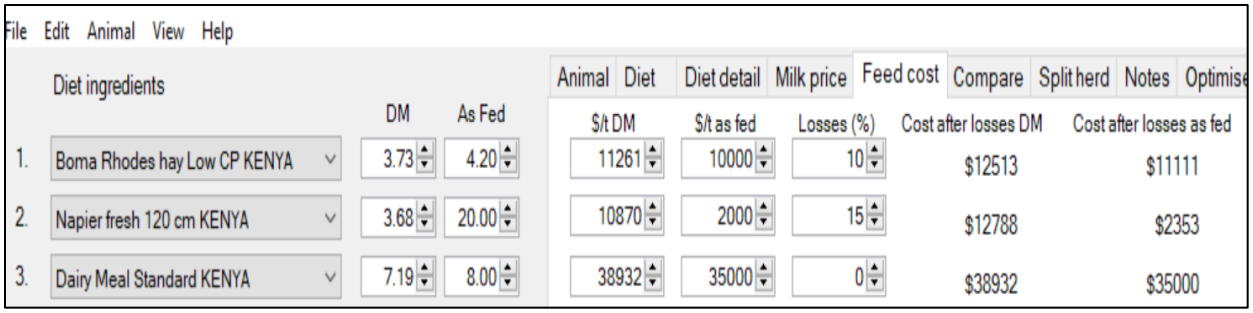


Figure 3.11: Feed cost parameters

3.4 Farm follow up and evaluation

As mentioned above, the visit frequency was on a monthly basis. Between consecutive visits, a minimum of two calls were made to the farm in order to monitor the implementation of the recommendations. Frequent calls were important in order to stay updated on feed market volatility, feed shortage or management challenges.

3.5 Piloting documentation and research work

The data collected during the piloting of Rumen8 was analyzed by two MSc students from Wageningen University who were embedded in the project, one after the other:

i. Pierre-Poublan

MSc thesis dated December 2018

Thesis title: Impact of balancing feed rations at medium and large-scale dairy farms in Kenya on milk production and margin above feed costs

ii. Dagmar Braamhaar

MSc thesis dated September 2019

Thesis title: Integration of diet formulation software in dairy farm coaching in Kenya. A pilot study

3.6 Lessons learnt from the piloting of Rumen8 on farms

The lessons learnt by the team piloting the software were:

i. Animal nutrition knowledge is essential for the safe, feasible and efficient use of Rumen8 on farms.
ii. Best forage management practices are key to improve farm performance. This can be achieved with best agronomic practices which influence the quality (in terms of ME, NDF, CP and digestibility) of fodder grown on-farm and being in control of cost of production of forages and feed costs
iii. Rumen8 or other diet formulation software are only useful when integrated in broader farm coaching programmes

CHAPTER 4. RUMEN8 DEMONSTRATION WORKSHOPS AND TRAININGS

4.1 Demonstration Workshops

These were one-day basic introductions of the capabilities of Rumen8 to a variety of audiences during the piloting phase of the software. These included:

i. Animal Production Society of Kenya held at Nanyuki and Nakuru on 4-6th April, 2018 and 9-11th April, 2019 respectively. Farmers, representatives of learning institutions, research institutions, government departments/ agencies and other stakeholders attended.
ii. Risa farm, Limuru on 13th July, 2018. Dairy farmers and other stakeholders in the dairy industry attended.
iii. Ngong Hills Hotel, Nairobi on 7th September, 2018. Dairy farmers and other stakeholders in the dairy industry attended.
iv. Ministry of Agriculture, Livestock, Fisheries and Irrigation (MALFI), Presentation to staff about results on 22 February 2019 of Rumen8 pilot to date.
v. Egerton University, Nakuru on 19th Oct, 2018: Post graduate students and lecturers were given introductory training.
vi. University of Nairobi (UoN), Upper Kabete on 5th December, 2018: Students and lecturers were given introductory training. From 6-11 May 2019, a one-week post-graduate training was given at UoN; see section 4.2.
vii. Roll out of the ASAL Counties Animal Feed Inventory 17th April, 2019, at the Kenya School of Monetary Studies in Nairobi, After the presentation of the ASAL Counties Animal Feed Inventory, the audience was given an introduction on Rumen8
viii. FAO-Kenya and FAO regional on 17th May, 2019 at FAO offices in attendance Robert Allport, Joseph Njuguna, Paul Opio
ix. Rawhide farm, Rongai on 13th June, 2019: Dairy farmers attended.
x. Three presentations about Rumen8 were given at the Kenya Market-led Dairy Programme / 3R Kenya Project Forage Seminar on 28 August 2019 at the Azure hotel in Nairobi.

4.1.1 Experiences during demonstration workshops of Rumen8

i. Lack of and inadequacy of laboratory analysis information of all feeds and forages as well as milk from the farms are main constraints and lower the reliability of predictions with Rumen8
ii. Incomplete or inaccurate herd records and individual animals and the weight of feeds given and left overs are a major constraint to proper demonstration of the potential of Rumen8 in making total balanced diet ration for dairy cattle easy.
iii. Farmers who graze their dairy cattle wish to be taught how to use Rumen8 on their own so that they can adjust their rations daily as grazing conditions change. This was successfully demonstrated in south western Uganda from 9-13 July 2019 with the Uganda R8 team

4.2 Trainings

This was a one-week basic training of University of Nairobi students and dairy consultants from Uganda on the use of Rumen8. This was held at the University of Nairobi, Upper Kabete campus

from the 6-11th May, 2019. It included classwork, take home assignments and field visits. The training was followed up with a 5 day training in Mbarara from 9-13th of July 2019 introducing optimization of diets and practical demonstration and use of Rumen8 at three Practical Dairy Training Farms

4.2.1 Experiences during Rumen8 training of consultants and University students

i. Delays in the program due to underestimation of time taken to view and review tutorial videos and assignments.
ii. Removal of sections of the program due to delays in the program, repetition of training materials and advanced knowledge required to understand some sections e.g. installation and use of Optimizer.
iii. Additions to the program to cater for important areas that were accidentally left out e.g. review of the mid- week farm visit.

4.2.2 Recommended improvements in future trainings

i. Trainees to install Rumen8 and the Sub-Sahara Feed Library at least a day before the start of the training.
ii. Training materials to be sent to trainees at least a day before the start of the training to reduce the need to print them.
iii. Reduction in the number of assignments given.
iv. More time allocation for review of assignments and tutorial videos.
v. Time allocation for review of the mid-week farm visit.
vi. Ensuring feed ingredients in the assignments have similar names as those in the shared feed library. All feed costs and dry matter percentages should also be included in the assignment guidelines.

4.2.3 Areas to be covered in future trainings

i. Start the training with Rumen8 in Compact Mode.
ii. Introduce Standard Mode after experience is gained with Compact Mode
iii. Use Optimizer function only if time and level of trainees allow it
iv. Downloading SAP Crystal reports and creating a pdf report
v. Importing and exporting feed ingredients and feed mixes
vi. How to create farm specific feed libraries
vii. Making transition cow diets
viii. How to monitor enteric methane emissions to create awareness for environmental issues
ix. Using the live weight change calculator
x. Feed ingredient limits
xi. Ca: P ratio in diets

APPENDICES

Appendix 1: List of feeds in the Sub-Sahara Africa feed library

Feed	Subgroups	Feed	Subgroups	Feed	Subgroups
African foxtail grass	4	Finger millet	1	Pinto peanut	2
Avocado seed	4	Fish meal	3	Poultry litter	2
Bamboo	2	Fodder beet	1	Pyrethrum marc	1
Bana grass	1	Groundnuts	1	Rapeseed	3
Banana	9	Guatemala grass	2	Rice	5
Barley	3	Guinea grass	4	Rumen protected fat	1
Bean	4	Kale	1	Salt (common)	1
Blood	1	Kikuyu grass	3	Sesbania	2
Rhodes grass	7	Kupakula	1	Setaria	3
Bone meal	1	Lablab bean	4	Siratro	2
Brachiaria grass	1	Leucaena	2	Sodium bicarbonate	1
Brewers grain	3	Limestone	1	Sorghum	5
Brewers yeast	1	Lucerne/Alfa alfa	4	Soya bean	3
Cabbage	1	Lupins	3	Star grass	5
Calliandra	2	Maasai love grass	2	Stylo	1
Carrots	1	Magnesium oxide	1	Sugarbeet pulp pellets	1
Cassava	4	Maize	24	Sugarcane	2
Centrosema	1	Meat and bone meal	1	Sunflower	6
Citrus	3	Megalac	1	Sweet potato	2
Columbus grass	1	Minerals	15	Tagasaste	1
Copper sulphate	1	Molasses	1	Teff	3
Copra meal	2	Mulberry leaves	1	Themeda	2
Cottonseed meal	4	Napier grass	4	Toxin binder	1
Couch grass	1	Natural grassland hay	2	Tropical kudzo	1
Desho/ Nigeria grass	3	Nigerseed	3	Urea	1
Desmodium	4	Oats	5	Vetch	3
Dicalcium phosphate	1	Pea hulls	1	Water hyacinth	1
Duckweed	1	Peak mix	1	Wheat	4
Faba bean	1	Pineapple waste	2	Yeast	1

The total number of feeds in the library is 233.

Appendix 2: Contacts of farms visited during the piloting of Rumen8

	Farms	County	Owner's / manager's name	E-mail address	Telephone number
1	Briaton	Meru	Zipporah Kiautha	zipporahkiautha@gmail.com	0721345570
2	Chemusian	Nakuru	Chris Kulei	chris@sovereignkenya.com	-
3	Chepseon	Kericho	Erik Koech/ Fred (manager)	info@chepseondairies.com korirkipfred@gmail.com	0721292717 0724736319
4	Gogar	Nakuru	Hamish Grant	grantgogar@icloud.com	-
5	Hill	Nyeri	Fr. Boniface Mwangi/ Br. Paul Kabiti	finance@adnyeri.org paulkabiti@gmail.com	0721382275
6	Illula	Uasin Gishu	Mr Magut (Manager)	johnmagut2@gmail.com	0723972803
7	Itigo Tophill	Nandi	Sammy Korir	-	0722261052
8	Gitonga	Meru	John Gitonga	-	0729521823
9	Joy	Nakuru	Francis Mwangi	francismwangigitau@gmail.com	0725551177
10	Kalia	Machakos	Nelson Nyamu	nelson.nyamu@physicaltherapy.co.ke	0724259789
11	Karimi	Nyeri	Mrs. Karimi	-	0722822378
12	Kentemere	Kiambu	Margaret Waithaka/ Harrison Maina	mwaithaka@yahoo.com	0722332234 0701044911
13	Kuzuri	Murang'a	Sophie Macharia	swmacharia1@gmail.com	0722370958
14	Lacata	Uasin Gishu	Laban Tanui	lacatainvestment@gmail.com	0721518885
15	Maitai	Meru	Mr Kiambati/ Mrs "	kiambatis@yahoo.com	0720230155 072376731
16	Meved	Kirinyaga	Annie Mwangi	annie.mwangi@meved.co.ke	0722839366

17	Mwiboini	Kirinyaga	Jaine Gichangi	tafrija90@gmail.com	0770042100
18	Naiposha	Nakuru	Carol Gatheca	-	0720820485
19	Olosian	Kajiado	Carol Odhiambo/ Cyprian	shemodhiambo@hotmail.com cyprianmentor@gmail.com	0711679512
20	Peaceline	Machakos	Stanley Mutua	-	0724903307
21	Pejima	Meru	Mr Philip / Eric	dep22pejima@gmail.com	0729851224 0721519591
22	PrimeB	Nyandarua	Dr. Kimani	jkimani@csrtkenya.org	0733719711
23	Rarama	Meru	Joseph G. Rarama	-	0722344404
24	Rehoboth	Machakos	Daniel Pakili/ Ruth Munyao	pakilidan@gmail.com kaluki2001@gmail.com	0712265800
25	Risa	Kiambu	Andrew Murugu / Samson Muthomi	murugua@molito.co.ke	0722572014 0721934093
26	RK	Meru	Rachael Kinyua	rachaeln.kinyua@gmail.com	0721449842
27	Sikiru	Meru	Edwin (manager)	-	0723635356
28	Small farm	Kitale	Felister Njoki	-	0725260478
29	Sprout farm	Kitale	Mr. Njoroge	-	0721379131
30	Westwood	Baringo	Robert Kotut/ Mrs Kotut/ Sammy Chesiyina/ Dan Kirwa	rkotut@karenroses.com dan@westwooddairies.com bob@karenroses.com schess@karenroses.com	0720704870 0722742214 0734818996 0710833420

Appendix 3: Number and date (YYYY/MM/DD) of visits made to farms during the piloting of Rumen8

Farms	1st visit	2nd visit	3rd visit	4th visit	5th visit	6th visit	7th visit	8th visit	9th visit	10th visit	11th visit
Briaton	20180920	20181016	20181211	20190129	20190227	20190326	20190425	20190522			
Chemusian	20180710	20180824	20181012	20181115	20181221	20190116	20190214	20190314	20190413	20190513	
Chepseon	20180831	20180918	20181010	20181116	20190118	20190219					
Gogar	20190216	20190315	20190420	20190516							
Hill	20180712	20180914	20181015	20181127	20190305	20190326	20190426	20190517			
Illula	20180914	20181009	20181120	20181217	20190125	20190220	20190319	20190415	20190511		
Itigo Tophill	20190318	20190417	20190509								
John Gitonga farm	20181214	20190201	20190301	20190329	20190427	20190520					
Joy	20180710	20180818	20180920	20181026	20181114	20181218	20190121	20190220	20190312	20190409	20190515
Kalia	20180912	20181016	20181108								
Karimi	20190227	20190327	20190425	20190521							
Kentemere	20180802	20180915	20181001	20181203	20190125						
Kuzuri	20190213	20190321	20190502	20190522							
Lacata	20180724	20180913	20181008	20181121	20181218	20190124	20190221	20190320	20190416	20190510	
Maitai	20180717	20190131	20190228	20190328	20190426	20190524					
Meved	20180718	20180913	20181012	20181126	20181219	20190117	20190223	20190330	20190430	20190523	
Mwiboini	20180816	20180927	20181030	20181207	20190122						
Naiposha	20190221	20190325	20190524								
Olosian	20180807	20181004	20181106	20181217	20190128	20190214	20190311	20190408	20190527		
Peaceline	20190226	20190328	20190423	20190518							
Pejima	20180716	20180918	20181018								
PrimeB	20180820	20180926	20181031	20181206	20190130	20190308	20190405				
Rarama farm	20181212	20190130	20190226	20190327	20190423	20190521					
Rehoboth farm	20180710	20180911	20181018	20181130	20190123	20190222	20190329	20190429	20190520		
Risa	20180721	20180803	20181011	20181107							
RK	20180919	20181018	20190130	20190226	20190327	20190423	20190522				

Sikiru	20180704	20180917	20181017	20181210	20190128	20190225	20190325	20190424	20190523		
Small dairies	20181025	20181117	20181219	20190123	20190223	20190321	20190418	20190528			
Sprout farm	20181026	20181222	20190109	20190222	20190322	20190419	20190527				
Westwood	20180904	20181123	20181220	20190117	20190215	20190313	20190412	20190514			

Date format YYYY/MM/DD

Appendix 4: Memorandum of understanding with Rumen8 farmers

MEMO: 13 JULY 2018
SNV KENYA / KENYA MARKET-LED DAIRY PROGRAMME (KMDP)
RUMEN8 FEED RATIONING FOR DAIRY FARMERS PILOT
COLLABORATION WITH SELECTED MILK SUPPLIERS/FARMS

Introduction

SNV KMDP has introduced and piloted in Kenya a feed rationing programme/software from Australia named Rumen8. To make the software useful for Kenya and other Sub-Sahara Africa countries, a Feed Library was populated (data from publicly available renowned sources) and the software underwent some adjustments to the needs of the Sub-Sahara Africa dairy farmers, as the Australian developers were willing to facilitate and cooperate.

The tool assists dairy advisors to inform the farmer as regards making an optimal ration for his cows, taking into account (amongst other factors) the breed/weight of the cow, the farming system under which the cow is kept, the expected/targeted milk production, the ingredients (nutritive values, weight and price) of the ration (including forages), and the milk price. The tool helps in maximizing the margin above feed costs and optimize the productivity of the cow, hence it seeks to increase economic performance of the dairy enterprise.

Over the past 3 months (April 2018 – June 2018) the software has been tested or applied in over 15 medium scale dairy farms in Kenya. The SNV Rumen8 Project Team in Kenya is ready to start using/further deploying the tool for farm advisory and impact measurement. This will be done during the period *July – November 2018* by focusing on 10 MSF farms with repeat visits/advisory and impact measurement of the optimized rations as regards feeding costs, productivity of the lactating herd and cow conditions, and margins above feed costs.

The SNV Rumen8 Team on the ground consists of: Mr Jos Creemers (ProDairy EA Ltd), Ms Angela Gitau, Mr James Kariuki, Ms Fridah Njoki (MSc students EGU), Mr Jackson Muchiri (UoN MSc student) and Mr Pierre Poublan (MSc student WUR, the Netherlands). The team is supported by Dr Hink Perdok from the Netherlands who has a long international career in animal nutrition, and Dr Martin Staines from the Australian Rumen-8 developers.

Expected collaboration Farm Owners and Managers (Farms)

- Farm *owners* need to confirm they are interested in the application of Rumen8 software (this pilot) and instruct their farm managers accordingly.
- Farms will fill in a Farm Profile template with information on (amongst others): name of farm, location, name/contacts details of owner and farm manager, herd size and composition, herd fertility, milk production, farm size and land used for fodder crops (incl. leased land), type of fodder crops grown/bought and fed, other feeds and minerals bought and prices.
- Farms are able and willing to share all relevant information required by the Rumen8 Team for advising them on an optimal feed ration (e.g. information on feed ingredients used, ration composition, quantities and prices).

- Farms need to have good record keeping in place and are willing to share KPIs on a monthly basis.
- Farms need to be willing to discuss, accept and implement mutually agreed advice of the Rumen8 Team and to change the ration based on the R8 Team advice.
- Farms (owners and managers) need to be available and accessible for consultation during the visit of the Rumen8 team and by e-mail and phone between visits
- Farms need to monitor and record impact on milk production and margin above feed costs, as per the guidelines and systems developed by the Rumen8 Team.
- Farms are willing to share all relevant information with the Rumen8 Team.
- Farms are willing to work with student from WUR to measure impact and report on the same.
- Farms need to be willing and interested to share the results and lessons learned with third parties, including peer farmers, and occasionally also to attend study groups (e.g. the other Bio Foods farms that are part of this project.

Expected inputs/deliverables from SNV Rumen8 Team (The R8 Team)

- At new farms, the Rumen8 Team will do a farm intake and apply Rumen8 based on the current ration and will calculate a more optimized feed ration of available feeds/fodders in the market. A report will be presented to the farm.
- The Rumen8 Team will discuss the report and the optimized ration with the farm owner and manager and agree on a new ration and feeding instructions/practice
- The Rumen8 Team developed a format for monitoring/recording and impact measurement of the changed ration and will instruct/train the farm owner/manager to populate this
- The Rumen8 Team will evaluate the results with the farm owner/manager and adjust the ration if and as required based on the results and impact recorded
- The Rumen8 Team will highlight other critical issues in the farm that affect cow/farm performance, including fodder production and preservation.
- The Rumen8 Team will pay a number of visits to the farm for advisory and data collection during the time span of 8 months.

Agreed on the date mentioned below by the parties mentioned below:

For:SNV Kenya/KMDP Anton Jansen Nairobi, ……..2018	For: Perfometer Ltd David Maina Nairobi, .. ……. 2018	For: Bio Food Ltd Jasper van den Brink Nairobi, ……2018	For: ……Farm Mr/Ms……. XXX, …….2018

Appendix 5: Example of a diet report

DIET REPORT

Recommended diet for early lactation cows

Diet created by Kenyan Rumen8 team

Animal

Liveweight (kg)	588	Milk yield (l)	25.7	Fat (kg)	0.90
LW change (kg/d)	0.0	Milk fat (%)	3.7	Protein (kg)	0.79
Days pregnant	0	Milk protein (%)	3.1	Fat + Protein (kg)	1.72
Days in milk	71	Fat:Protein ratio	1.19	Energy corrected milk (kg)	24.3

Diet/cow/day

#	Ingredient	kg DM	kg As Fed	ME (MJ)	CP (g)	Ca (g)	P (g)	Mg (g)
1	*Maize silage DM < 30% KENYA*	*5.89*	*22.48*	*58.3*	*383*	*15.3*	*11.2*	*7.1*
2	*Dairy Premix (Mlavit) KENYA*	*0.03*	*0.03*	*0.0*	*0*	*2.8*	*0.9*	*0.5*
3	*Luceme fresh KENYA*	*0.74*	*3.00*	*6.7*	*148*	*12.1*	*2.1*	*2.5*
4	*Boma Rhodes hay Low CP KENYA*	*2.04*	*2.30*	*13.1*	*98*	*9.2*	*7.1*	*2.9*
5	*Sunflower seed cake partly dehulled CF <> 200-*	*2.27*	*2.50*	*22.9*	*742*	*11.8*	*22.2*	*13.6*
6	*Soyabean cake fat < 40 g/kg KENYA*	*1.25*	*1.40*	*16.8*	*601*	*3.8*	*9.5*	*4.0*
7	*Rapeseed cake fat < 40 g/kg KENYA*	*0.81*	*0.90*	*9.6*	*328*	*6.2*	*9.9*	*4.4*
8	*Maize germ cake fat < 40 g/kg KENYA*	*1.68*	*1.90*	*20.5*	*235*	*1.7*	*10.9*	*4.2*
9	*Maize grain KENYA*	*1.77*	*2.00*	*24.6*	*165*	*0.5*	*4.6*	*1.8*
10	*Wheat bran KENYA*	*0.97*	*1.10*	*10.8*	*160*	*1.5*	*9.7*	*4.7*
11	*Rice bran CF < 40 gr/kg KENYA*	*0.90*	*1.00*	*14.2*	*128*	*0.5*	*12.5*	*5.5*
12	*Minerals Afya Bora Mazivia KENYA*	*0.15*	*0.15*	*0.0*	*0*	*27.0*	*18.0*	*4.5*
13	*Limestone (CaC03) KENYA*	*0.04*	*0.04*	*0.0*	*0*	*13.6*	*0.0*	*0.3*
14	*Wheat pollard KENYA*	*0.89*	*1.00*	*10.7*	*140*	*1.1*	*4.4*	*2.7*

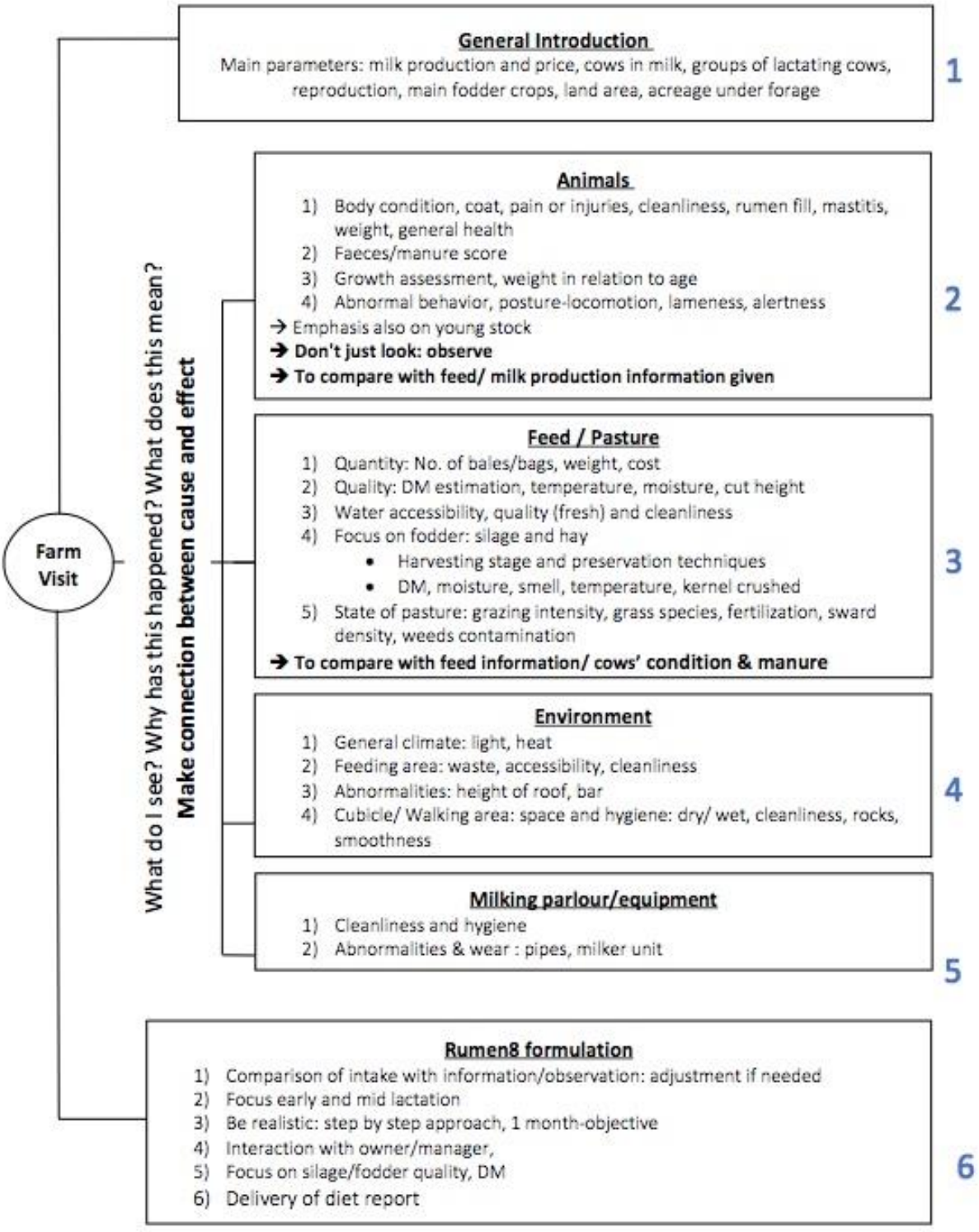
Total/cow/day	kg DM	kg As Fed	ME (MJ)	MP (g)	Ca (g)	P (g)	Mg (g)
Supply	19.4	39.8	208	1,877	107.1	123.1	58.6
Demand			201	1,878	108.2	66.2	35.1
Balance			7	-1	-1.0	56.9	23.5
% Requirement			103.4	99.9	99.0	185.9	166.9

Total Diet				Feed Efficiency		Margin	
% of DMI limit	102	ME density (MJ/kg DM)	10.7	kg ECM/kg DM	1.3	Milk income/cow/day	$1,542.00
NDF (%DM)	39.1	CP (%DM)	16.1	gm MS/kg DM	89	Feed cost/cow/day	$650.13
Starch (%DM)	21.3	RDP (%CP)	71.0	$ Milk / $ Feed	$2.37	MOFC/cow/day	$891.87
Forage:Conc ratio	45:55	UDP (%CP)	29.0				

Notes Rumen8 diet summary report printed 11/6/2018 2:56PM

Milk price at KES 60 per liter. Recommended diet from previous visit predicted an increase in milk production of a selected group of cows from 23.1 to 25l/cow. Average milk production 20181106 of the same group of cows 25.7l/cow/day.

Appendix 6: Farm visit protocol



NB. **To bring**: small weighting scale digital with bag, measuring tape, printer and projector if needed

Appendix 7: Changes made to Rumen8 at the request of Kenyan Rumen8 team

Version 3.3.0.6

- Fixed a bug that allowed entry of milk prices just over the maximum 999/L
- Fixed a bug that increased milk prices in the save file

Version 3.3.0.5

- Fixed a bug that prevented some mix dry matter contents being calculated due to a rounding error.

Version 3.3.0.4

- Fixed a bug that incorrectly calculated the mix dry matter cost if the cost on an 'as fed' basis was entered.
- Fixed a bug that allowed a new mix to be saved with no name.

Version 3.3.0.3

- Protein demand by the cow is now calculated using the 'Feed into milk' standard. Rumen8 will change to this method automatically when it starts for the first time. Using the previous AFRC method is not recommended but can be selected in the advanced preferences
- The cow protein demand model has been updated to the 'Feed Into Milk' standard.
- The currency now defaults to the system symbol and can be changed in the preferences.
- Currency cents can be turned off in the preferences
- Diet ingredients can be dragged from the ingredient number and dropped on another ingredient number or name to swap the position of the two ingredients.
- When importing feeds and mixes you can now choose to use feeds already in the feed library if they have the same parameters (other than the name).
- Multiple feeds and mixes can be deleted at once in the feed editor
- The cost of feed ingredients is displayed in the mix editor
- Enteric methane production has been added to the diet copy/ paste function
- Improved sort buttons layout in the feed editor
- Feed lists update more quickly in the feed editor.
- Import and export feeds now prevents you from exporting to or importing from the current feed library.
- Silage 'Feed protein type' may be incorrectly classed as 'Grass silage' instead of 'Other silage' when editing. Note: Rumen8 will correct all the provided non-grass silages on start up. User created feeds will also be corrected if their name is the same as the Rumen8 provided feed with the addition of a suffix.
- The methane intensity units now change correctly based on milk units.
- Feed import settings and folder paths are now remembered between sessions.
- Bug fixed that allowed feed or mix edit after import without feed or mix selected

Version 3.2.3.0

- Methane production by the cow added to the diet detail tab.
- Diet ingredients weight as fed appended to data copied to the clipboard by the Edit->Copy menu items

- Total fat in the diet is now reported in the fat% tool tip on the Diet detail tab.

Version 3.2.2.5

- Active recommended levels now shown in the tool tips for the small traffic lights on the Animal tab and constraint range on the Optimiser tab.
- Optimiser update message links to correct section of the User guide.
- Optimiser updater improved.
- Missing feed library file message now exits correctly if the user chooses no.
- Diet comparison reports can now be saved to PDF files
- Diet comparison reports no longer display 0's for empty compare diets.

Version 3.2.2.3

- The dry matter intake estimation method has been moved from the preferences to the animal tab. It no longer applies to all animals but is specific to the current cow. parameters to adjust how the standard and NDF methods estimate dry matter intake of the current cow remain in the preferences.
- NDF intake potential can be set individually for cows, dries, transition cows and heifers in the preferences.
- Standard intake potential now has user preferences for dry and transition cows
- Dry matter intake for NDF on the diet detail tab now shows the target quantity in the tool tip
- Recommended levels sets in the preferences can now be linked to a cow days in milk range and will change sets automatically. Switching between automatic and manual selection of recommended levels can be done on the diet detail tab via a new A/M button
- When opening a saved diet, you will be warned if the intake potential parameters have changed since the diet was saved. This is on by default in the Preferences.
- When opening a saved diet you can be warned if the milk price has changed since the diet was saved. This is off by default in the Preferences.
- The Split herd tab can now be hidden in the preferences if you don't have split calving herds.
- DCAD has been added to the diet report.
- The diet tab progress bars and percentage values now show actual values in the tool tip
- Intake potential estimation methods renamed to standard and NDF
- Intake potential method is now a property of the cow and set on the animal tab, not a preference setting applied to all animals.
- The NDF recommended level maximum has been increased from 50 to 70%
- Forage: Concentrate ratio now reports 0:100 or 100:0 instead of -if the diet is all one type
- The optimizer parameter sliders have been widened to make them easier to set accurately
- Recommended levels for NDF from forage as a percentage of liveweight now save correctly
- Feed costs in the diet detail window now display correctly when greater than $9999
- Feed as a percentage of income now displays percentages greater than 100
- A bug in the MilkPrice.db3 upgrade routine that caused an occasional failure during the upgrade has been fixed.

Version 3.2.1.2

- Fixed bug that displayed nonsense for the equivalent milk prices for dry cows
- Fixed a bug that reset the heifer weight to 40kg under unusual conditions.

Version 3.2.1.1

- Fixed bug that allowed quitting without prompting to save changes.

Version 3.2.1.0

- New diet comparison report added.
- Warnings added to the diet ingredients if the maximum feeding rate is exceeded.
- Warnings added if daily DM intake exceeds 25 kg/d or 4% of live weight.
- Diet ash content added to the Diet Detail tab (organic matter in tool tip).
- A fifth set of recommended levels added along with an off option. Now allows parameter ranges for early, mid & late lactation plus dry and transition herds.
- Maximum milk price increased to $9999.99.
- Milk price now changes to cents per kilogram when the milk units are kilograms.
- Cow liveweight change calculator BCS revised and includes Penn State 1-5 system.
- Penn State BCS system added to the live weight change tool tip.
- Fixed a bug that prevented some diet costs saving.

Version 3.2.0.1

- Fixed a bug in the calculation of the $Milk/$Feed efficiency parameter.
- Feed costs are no longer displayed if any diet ingredient is missing its cost.

Version 3.2.0.0

- Heifer mineral demand has been added.
- Standard cows with 2000, 3000 & 4000 liters lactations have been added.
- Restoring a stored diet now has the option to also restore the animal.
- The maximum feed cost has been increased to $9999999/ton.
- The herd margin will now display negative margins.
- Shift clicking a diet ingredient will remove that ingredient.
- The Feed editor import cancel button changed to Skip All to make the function clearer.
- Added tool tips to the Feed editor import CSV buttons.
- Changed the Import, Diet menu text to make the function clearer.
- Pasted forage: concentrate ratio increased to 2 decimal places and the title is clearer.
- Calculated ingredient amount (fresh from entered dry matter and vice versa) now rounded to 2 decimal places to prevent inconsistencies.
- The report disclaimer entry box style now matches the others.
- Expanded the explanation for excess protein removal cost tooltip and changed units to KJ/g N.
- Expanded the Excess protein forgone milk explanation in the tool tip.
- Provided grams of MP/liter of milk table in the tooltip for true protein concentration on the Animal tab.

- Added MP efficiency coefficients to the MP Detail window.
- Updated the DCAD reference on the About window and Diet Detail tool tip.
- Improved wording of save default animal dialog box.
- Improved wording in the User Feed Library flag tooltip.
- Improved wording for menu option to move dry cow into transition herd.
- Fixed a bug that prevented the eNDF recommended levels traffic light from working.
- Fixed a bug that prevented the forage:Concentrate recommended levels traffic light from turning off when no diet was loaded.
- Fixed a bug that prevented the recommended DCAD levels being updated to the 2017 values.
- Fixed a bug that prevented restoring the Split Herd diet in some circumstances.
- Fixed bug that blanked wet cost when dry matter cost was entered as 0 and vice versa in feed and mix editor.
- Fixed calculation of the non-entered cost when the dry matter of the mix is changed, and the mix is complete.
- Numerous internal updates to allow easier code maintenance and future updates.

Version 3.1.2.0

- Improved the heifer protein demand calculation by replacing the default 1.25 MP adjustment with a correction factor based on live weight (Tedeschi 2015). This will increase heifer protein demand.
- Expanded tooltip information in Preferences for MP requirement adjustment and NDF intake as a percent of live weight.
- Added the NDF intake as a percent of live weight to the Max DMI NDF% value on the Diet Detail tab.

Version 3.1.1.4

- Bug fixed that prevented ingredient 10 restoring correctly from the Compare tab.
- Fixed a calculation error on the Diet report for ingredient mineral supply.
- Fixed the calculation of mix mineral absorption rates.

Version 3.1.1.3

- The Diet report now allows negative margin over feed costs and larger dollar values.
- Added dry matter intake as a percentage of cow live weight to the Diet detail tab.
- Added tool tips to the Milk price tab headings.
- The minimize and maximize controls have been restored to the main windows.
- Fixed a mix cost bug that prevented fresh weight costs being entered.
- Fixed bug where preference validation values were not being read from the file correctly.

Version 3.1.1.2

- Fixed occasional bug when importing an old diet file after a failed attempt to import a non-Rumen8 csv file.
- Improved milk prices database upgrade process.

Version 3.1.1.1

- Additional information about the MP Correction Factor added to the User Guide, Help and tooltip in the Advanced Preferences.
- Fixed bug when importing version 2 feed library.
- Fixed bug when exporting mixes.

Version 3.1.1.0

- Diet, Batch and Feeding reports can be printed or saved as PDFs from the File menu (reports require the SAP runtime software to be installed, see Getting Started in the User Guide for details).
- Easily share feeds and mixes by exporting and importing them from the Feed Editor Selection tab.
- Combine separate diets for split herds in the new Split herd tab.
- Define up to 12 milk price sets in the Milk Price tab.
- Create diets for heifers by selecting a heifer in the Breed & Maturity drop-down menu.
- Calculate the target growth rate for heifer herds with the calculator on the Animal tab.
- Suggest cow live weight change with the calculator on the Animal tab.
- Estimate the additional liveweight change required to increase body condition score in the cow live weight change calculator.
- Milk fever risk is estimated for transition cow diets on the Diet Detail tab.
- There is now a warning on the Diet tab if a monitored parameter on the Diet Detail tab is out of the recommended range.
- Animal parameters can be entered directly on the Animal tab in addition to using the sliders.
- The updated User Guide is now available from the Help menu, the F1 key or the help button (?) in the window title bar.

Appendix 8: Guidelines for Forage Maize Production and Ensiling

KMDP with input from the partnering contractors developed a booklet and a poster containing Guidelines for Forage Maize Production and Ensiling. These Guidelines are copied below and can be downloaded from: https://www.cowsoko.com/programs/kmdp/publications Report nr 35
The Guidelines were presented at a Field Day in Eldoret on 6 February 2019. For the videos see: https://youtu.be/12U7bkc1qrM https://www.youtube.com/watch?v=ytgsuMtqhTQ#action=share

1. PREPARATION / PLANNING		
What	*How*	*Why*
a. Maize silage	To plan and prepare more acreage for maize silage not only to overcome seasonality in milk production, but more to be a constant component in animal nutrition.	Maize silage provides low cost metabolizable energy (ME) for dairy cows and is a key ingredient in the cow's daily feed ration. If prepared in enough quantity, it also helps the farmer to counter seasonality in milk production. Whether maize silage is cost effective depends on quality, cost of production (and price in the market if bought externally), vis-a-vis other available feed and forages in the market.
b. Target high quality forage	Invest in land preparation, focus on right stage of harvesting and for high capacity make use of contractors.	To make better use of the (genetic) potential of the dairy cow and enhance milk production. To reduce the cost per unit of ME fed to the cows and per litre of milk produced. To make feed management more flexible
c. Minimize cost of production	Focussing on higher yield per acre reduces cost of production per kg of DM.	To seek to maximize efficiency and quality in each step of the silage making process (from seed to feed). Consider costs of hiring specialized contractors versus buying and operating own farm machinery. Is it more lucrative to outsource?
d. Feed planning	Use of a feed planning tool	To balance feed requirements based on number of cows and expected milk production with acreage under forage production and/or purchased forages.
2. LAND CULTIVATION		
What	*How*	*Why*
a. Field selection	Select suitable fields for forage production	To make field characteristics: a) soil type, b) soil fertility, c) accessibility, d) suitability for mechanization.
b. Ploughing	Plough with a mould board plough or a fixed chisel tine cultivator with levelling harrow attached. Avoid disc ploughs!!	Completely turns the soil, breaks hard pan, increases soil aeration, reduces soil erosion, levels the field.
c. Seed bed preparation	Cultivate to a fine tilth and level by cross cultivating.	To encourage uniform growth of plants, maximum exposure to sun, increase germination rates, easy machine operations, etc.

3. SEED SELECTION		
What	*How*	*Why*
a. Seed variety	Select forage maize variety or hybrid suitable for forage production i.e. with low NDF, stay green, cob stem ratio of 50:50 (on DM basis) and high in starch, and gradually maturing.	Good variety means good quality feeds (high energy/kg dry matter and high digestibility/kg organic matter), optimum crop yields, suitable varieties that can stay green even after ripening. Because there are no forage maize varieties available in Kenya (only for grain) we have to look for those available varieties with characteristics that come closest to forage maize (see "How")
b. Seed size	The size of the seed should suit the planter to be used.	This will ensure that the machine drops the correct number of seeds, resulting in the desired plant population per acre or hectare
4. PLANTING		
What	*How*	*Why*
a. State of implement	Check the settings of the planter. Fertilizer placement should be 5 cm beside and below the seed. There should be no blockage.	To prevent scorching of the seeds, to ensure seeds are able to drop through the perforated plate, to ensure the correct seed rate is obtained.
b. Seed rates	Determine the correct seed rate to get the desired plant population.	To avoid plant competition and ensure maximum yield per acre or hectare.
c. Fertilization	Analyse the soil: supplement the required amounts of nutrients at planting and top dressing as per the soil analysis.	To ensure that the amount of fertilizer supplied meets the deficit and to avoid waste of fertilizer and money in case of oversupply.
5. CROP PROTECTION		
What	*How*	*Why*
a. Weed control	Use appropriate herbicide in the recommended concentration; apply correctly and under right conditions	To maximum yields, to avoid silage contamination by weeds, and to make harvesting of the crop by machine easier.
b. Pest control	Use appropriate pesticide in the recommended concentration. Apply correctly and under the right conditions.	To avoid losses through pest attack. To maximize production per acre.
6. HARVESTING		
What	*How*	*Why*
a. Stage of harvesting	Aim at a DM level of the whole crop of 30-35% and a starch level of at least 30%. The most accurate method of deciding when to harvest is to determine the dry matter on samples of the whole maize plant. DM can be determined with a probe, by NIRS or in an	If machines with a well-functioning kernel crusher are available it is advised to ensile at a high DM content of 32-35% to maximize starch and ME levels. The energy in maize silage mainly comes from the starch in the cob and the energy level of the total crop increases as the plant matures. This happens in spite of an increase in the NDF content of the stem and a consequently lower energy content of the stem. Longer stubble length improves digestibility and energy content, as the stubble is high in NDF.

	oven. The kernel should be at dough ripe stage.	
b. Machine to be used (kernel crushers) and servicing	The machine should have a kernel crusher. The machine needs proper preventive maintenance and servicing during harvesting (e.g. calibration and sharpening of knives).	The kernel crusher allows for harvesting at a higher DM and starch content (dough ripe stage) and silage with higher energy content per kg DM. Chaff cutters usually do not have a kernel crusher which forces the user to harvest at milk ripe stage. At this stage the total crop has not reached its maximum energy (i.e. starch) content, as sugars in the kernels have not yet converted into starch, the DM of the silage is too low, and nutrients will be lost through effluent wastage.
c. Additives	Adding inoculants based on lactic acid bacteria.	Even if good silage preservation is expected certain inoculants can improve silage quality reduce losses and raises animal production. Additives will never compensate poor crop production or silage management!
d. Location of silo or trench	Determine how far the clamp/pit is from the barn, how well-drained the location is, how safe from any other traffic and from birds, rodents and wild animals.	The clamp/pit should be on a dry well-drained area to avoid dampness, rainwater stagnation and animals from entering the pit. When the crop has been harvested too early, there should be space for the effluent to drain-off.
e. Weather	Check the weather if appropriate for machines to enter the field and right for harvesting.	Monitor weather pattern and forecast so as to bring machines at best conditions. This will avoid machines to get stuck and delays in the process, and contamination of silage with mud. It maintains silage quality.
7. CHOPPING AND KERNEL CRUSHING		
What	*How*	*Why*
a. Chopping length	The machine used should be able to chop the crop into pieces of 8-12 mm.	This will reduce losses, enables easier compaction, increases voluntary feed intake per cow and avoids selective feeding.
b. Kernel crushing	The machine used should be able to crush the grains into at least 3 parts each.	This will ensure that the starch in the grains is faster available for bacteria that produce acids, thus preserving the silage. Moreover, the cows will better digest crushed kernels and whole grains will not be seen in the dung.
8. TRANSPORTATION		
What	*How*	*Why*
a. Distance of field to pit	The distance should be as short as possible.	Unless more trucks or trailers are used, the shorter the distance, the faster the filling of the pit and the better the quality of the silage. A pit/clamp should always be filled, compacted and closed within 12 hours.
b. Truck or tractor	Should be selected depending on distance, access and state of roads.	The machine used should transport fast and efficiently to shorten time between chopping, compaction and covering. Plan in a way that the trench can be closed within 12 hours after filling starts.

c. Accessibility and field conditions	The field and farm should be accessible to the forage harvester but also to trailers and trucks when loaded.	The farm should have good accesses roads, the maize fields should be accessible to the machines. Large (e.g. 6 rows) self-propelled maize choppers need more space than smaller machines. The fields should be level and free from stones, tree stumps and other obstacles that can cause damage to the harvesters and the loaders.
9. COMPACTION		
What	*How*	*Why*
a. Machine / equipment	The silage should be compacted using the heaviest machine available: a tractor or a shovel.	This is to remove as much oxygen as possible from the pit to create the necessary (anaerobic) conditions for conserving the chopped maize. Good compaction is necessary to prevent the silage from heating during the ensiling process and feeding out.
b. Pit dimensions	The dimensions should be designed to give appropriate feeding speed of 1.5 to 2 meters per week. Narrow and long is better than short and wide. Ensure sufficient height of the trench.	The dimensions should tally with the number of cows to ensure good feeding speed of 1.5 to 2 meters a week and hence to minimize losses by heating and moulds.
c. Shaping of the pit	The sides should be as upright as possible. Avoid flat “chapati shaped” edges.	The sides should be slightly less than 45 degrees to minimize the surface area exposed to air/oxygen and to ensure firm edges.
d. Layering and spreading	Spread and compact each layer the moment it is tipped, i.e. keep a shovel or tractor on the pit during the ensiling process.	Each layer should be compacted to obtain properly and homoge-neously compacted silage. Continuous compaction will eliminate air more effectively.
10. COVERING		
What	*How*	*Why*
a. Sealing	Seal silage pits or clamps immediately when that particular pit has been filled.	Ideally within 12 hours from the start of making the pit/clamp.
b. Choice of plastic	The polythene should be preferably one continuous sheet, without any holes, of good gauge (>500) specially produced for silage making. Many farmers use a second, heavier gauge sheet to protect the vulnerable polyethylene sheet.	The airtight plastic prevents oxygen from entering the pit. The one sheet plastic is best because there are no uncovered edges that can allow penetration of air into the silo. The economic value of well-preserved silage is high, and it can be cost-effective to invest in a heavy-duty outer sheet.
c. Covering	Dig a trench around the pit, place plastic, tighten the plastic with soil around the pit, and gently place soil up to 15 cm (6 inches) thick on the top and sides of the pit. Do not puncture the	Soil or sand bags keep the polythene sheet tighter to the silage and continue exerting pressure on the silage pit. Tires are not preferred as they do not keep out the heat and sometimes wires stick out of old tires that can damage the polyethylene sheet.

	polythene; repair holes before covering with soil.	
d. Fencing	Fence-off the area to keep away animals from walking on the pit.	If cows are moved or grazed and there is access to the silage pit/ clamp, they can walk on the silage bunker and the hooves can make holes in the plastic. Fencing keeps the livestock away.
e. Inspection	Fence-off the area to keep away animals from walking on the pit.	If cows are moved or grazed and there is access to the silage pit/ clamp, they can walk on the silage bunker and the hooves can make holes in the plastic. Fencing keeps the livestock away.
e. Inspection	Weekly walk around the silage pit/ clamp/bales.	Inspect the silage pit/clamp/bales at least once a week. This to ensure equal and sufficient soil cover (it may have washed off with heavy rain) and to repair holes in the polythene made by rodents, birds or wildlife.
11. MANAGEMENT & FEEDING-OUT OF SILAGE		
What	*How*	*Why*
a. Feeding speed	The feeding speed should be 1.5 - 2 meters per week based on the feed planning tool.	To prevent heating, moulding and rotting at the face of the silo.
b. Ease of removing	Make sure the silage can be removed easily and is accessible.	If silage removal takes great effort, staff will attempt to remove less than necessary. Make sure to remove corners every day and keep the face of the silage clamp straight and tight.
c. Removal of silage	Remove all loose materials from the open side (face) of the pit and feed immediately.	Loose materials in front or on the bottom of the silage pit or clamp cause moulds and rotting bacteria to grow. From here moulding and rotting will spread to the good parts of the clamp.
d. Cleanliness around	Clean the open silage face from all rotten and loose materials daily.	This removes moulding and rotting materials hence preventing contamination of good feed.
e. No cover on open silage face	Do not cover the open pit or clamp with polythene but keep the face open.	A loose cover will not avoid air coming in, but it may protect against rain. However during warm days the cover in front creates a microclimate suitable for multiplication of moulds and bacteria in the silage.
f. Feeding space	Provide enough feeding space at the feeding rack in the cow barn. A minimum of 65 cm per cow is recommended to ensure a high feed intake.	To avoid competition at the feeding trough or feeding barrier, to give each animal the opportunity to eat the same diet and to ensure enough space for all animals to eat at the same time.
g. Avoid losses during feeding.	Cows should not trample or foul the silage. Feed regularly and not in excess, only what animals can eat between two successive feeding. Keep feed-out areas, feed troughs	High feed quality will reduce wastage. Good feeding facility will reduce losses (waste and left overs).

	and feed alleys clean to prevent contamination of fresh batches.	
12. WHOLE SILAGE MAKING PROCESS / EVALUATION		
What	*How*	*Why*
a. Field operations	Record keeping of all field activities (plot number, date, activity, cost, result).	To determine whether all operations were done at the right time, speed and compaction. What could have been done better, how can it be improved?
b. Inventory of all pits/ clamps/bales	Calculate total tonnage of silage stored.	When the total stock of maize silage and other feeds is known a feeding plan for the dairy herd can be made for the coming year.
c. Sample each silage pit for analyses of nutritive value	Use feed analysis to monitor silage quality and for ration calculation/formulation.	To have insight in the quality and nutritive value of the silage, and the effect of good/bad silage practices. To determine which other feeds are required to balance the ration for the different cow groups. To monitor if the production of the cows is in line with the analysed quality of the silage.
d. Storage losses	Monitor/observe losses in the storage area pit/clamp/bale.	To explain and avoid in future the cause of the losses, and/or to ask your nutritionist for advice on how to reduce losses.
e. Feed-out losses	Estimate feed-out losses.	To ask yourself how the feed-out losses can be reduced.
f. Silage cost per kg intake	Monitor/re-calculate silage costs.	Assess possibilities to reduce cost per kg of silage. To calculate the costs per kg silage DM for comparison between silages with a different DM content.
g. Evaluate the silage making process with the contractor	Make calculations, pictures and exchange experiences.	To improve the results for all actors involved in the silage making and feeding process.

Appendix 9: Rumen8 Kenyan team contacts

	Name	Company/ Institution	Email
1.	Jos Creemers	ProDairy E.A. Ltd	jos@prodairy.co.ke
2.	Angela Gitau	Perfometer Agribusiness Ltd	angela.perfometer@gmail.com
3.	James Kariuki	Perfometer Agribusiness Ltd	jamesk.perfometer@gmail.com
4.	Patrick Ndungu	Perfometer Agribusiness Ltd	patrickndungu1821@gmail.com
5.	Julius Kosgei	SNV/KMDP Eldoret	kosgeijk@gmail.com
6.	Matt Agesa	SNV/ KMDP Eldoret	mattagesa@yahoo.com
7.	Paul Mambo	SNV/ KMDP Meru	mapaul4@yahoo.com
8.	John Fredrick Ochido	SNV/ KMDP Meru	joffreybig@gmail.com
9.	Jackson Muchiri	SNV/ KMDP Nairobi	jackson.muchiri85@gmail.com
10.	Frida Njoki	SNV/ KMDP Nairobi	fridanjoki10@gmail.com
11.	Emmanuel Ewaju	SNV/ KMDP Nairobi/ Egerton University	ewajuemmanuel@gmail.com
12.	Pierre Poublan	SNV/ KMDP Nairobi/ Wageningen University	ppcouzardot@gmail.com
13.	Dagmar Braamhaar	SNV/ KMDP Nairobi/ Wageningen University	dagmar.braamhaar@wur.nl