Data Article

Data describing cattle performance and feed characteristics to calculate enteric methane emissions in smallholder livestock systems in Bomet County, Kenya

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A B S T R A C T

This dataset describes the performance of cattle in smallholder livestock systems of Bomet county in western Kenya. Information on live weight, milk production and quality, herd dynamics, and other production parameters were collected from field visits. Animals were weighed on scales; milk yield was recorded using a Mazzican® milk collection and transport vessel provided to each farm and milk was analyzed for butterfat content (%). Pasture biomass yield was determined, and feed samples collected for each agro-ecological zone and nutrient composition was determined for nitrogen (N) using the Kjeldahl method and gross energy (GE) using a bomb calorimeter. Distance covered while grazing was determined using GPS collars fitted to several animals for three consecutive days per area. Enteric methane (CH₄) emissions factors (EF) were estimated for five animal classes to develop site-specific EFs as per the Intergovernmental panel on cli-

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climate change (IPCC) protocol. This dataset has the potential to be used, amongst other purposes, for animal-scale life cycle assessment (LCA) to evaluate the efficacy of various greenhouse gas (GHG) mitigation options.

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### Specifications Table

| Subject                     | Agricultural Sciences |
|-----------------------------|-----------------------|
| Specific subject area       | Livestock Sciences    |
| Type of data                | Tables                |
| Figure                      |                       |
| How data were acquired      | On-farms data collection for live weights, feed quantity and quality and animal productivity and modeling for emission factors |
| Data format                 | Primary (animal demographics, live weight, milk production, milk butterfat, feed N and GE), filtered (calving, weaning, and mortality rate, distance covered during grazing), and analyzed (enteric CH4 EFs) |
| Parameters for data collection | 131 smallholder farms selected through random stratification by location in Bomet County including 1,135 cattle in four agro-ecological zones (AEZs) |
| Description of data collection | 9 farm visits over a 12-month period, 5 live weight measurements per animal, 4 pasture sample collections per locality, 4 milk quality assessments done (one per lactating female every three months), 2 farm surveys done after six months, daily grazing distance estimated once and daily milk production recording. |
| Data source location        | Bomet (0°48′0.00″ N 35°13′59.88″ E) in Western Kenya |
| Data accessibility          | Data is included in this article |
| Repository name: Mendeley Data | (https://data.mendeley.com/) |
| Data identification number  | 10.17632/j5b9d7dd2b.2 |
| Direct URL to data:         | https://data.mendeley.com/datasets/j5b9d7dd2b/2 |
| Related research article    | Goopy, J. P., Ndung’u, P. W., Onyango, A., Kirui, P., & Butterbach-Bahl, K. (2021). Calculation of new enteric methane emission factors for small ruminants in western Kenya highlights the heterogeneity of smallholder production systems. Animal Production Science, 61(6), 602-612. doi: https://doi.org/10.1071/AN19631 |

### Value of the Data

- Uniquely high-resolution dataset combining animal characteristics, animal performance, feed quality, and the enteric methane emission factor (EF).
- Among the first reliable source of primary data to investigate African livestock systems' contribution to climate change at the individual animal scale.
- The EFs from this dataset can be used to evaluate the environmental impacts of these systems and facilitate the identification of contributing factors.
- The datasets can also be used to estimate the carbon footprint (CF) of smallholder livestock systems using the life cycle assessment (LCA) approach, thereby elucidating mitigation options across the supply chain.
- This dataset presents the differences between region-specific activity data and emission factors (known as Tier 2) factors and the Intergovernmental Panel on Climate Change (IPCC) default values (Tier 1) and activity data used to develop these default values.

### 1. Data Description

Data provided here describes the activity data of smallholder livestock systems. The climatic conditions of the agro-ecological zones (AEZ) in Bomet, Kenya are shown in Table 1, Table 2
shows herd dynamics, and the movement of animals in and out of farms through sales and purchases according to AEZs. Table 3 presents the cattle herd production parameters. The seasonal average live weight (LW) (Table 4) and seasonal live weight changes (see Fig. 1). There was the seasonal effect on weight change i.e., negative weight changes among the adult cattle and lower weight gains in the growing herd during the dry season due to feeding shortages while in subsequent wet seasons, there was a positive weight change. Table 5 shows the area of land allocated to the main animal feed resources and pasture biomass yield (Table 6) determined because it
Table 3
Summary of production performance parameters for Bomet cattle herd.

| Production Parameter | Yield/Rate |
|----------------------|------------|
| Milk production (liters/day) | 4.44 |
| Milk butterfat (%) | 4.20 |
| Average distance walked during grazing (km/day) | 8.05 |
| Birth rate (%) | 33.3 |
| Weaning rate (%) | 28.3 |
| Mortality rate (%) | |
| Females (>2yrs) | 3.0 |
| Males (>2yrs) | 12.1 |
| Heifers (1-2yrs) | 0.01 |
| Young males (1-2yrs) | 0.0 |
| Calves (<1yr) | 6.8 |

Table 4
Live weights (kg, mean ± standard error of means) for females and males (>2years), heifers and young males (1–2 years) and calves (<1year) under four seasons at 4 agro-ecological zones in Bomet County.

| AEZ   | Animal Class (1-2yrs) | S1 (LW, kg) | n  | S2 (LW, kg) | n  | S3 (LW, kg) | n  | S4 (LW, kg) | n  |
|-------|-----------------------|-------------|-----|-------------|-----|-------------|-----|-------------|-----|
| LH1   | Female adults (>2yrs) | 310.4±6.16  | 144 | 313.3±6.21  | 136 | 321.8±6.40  | 125 | 320.1±6.77  | 120 |
|       | Male adults (>2yrs)   | 267.7±46.79 | 5   | 235.0±58.99 | 6   | 244.8±49.91 | 6   | 248.7±49.53 | 6   |
|       | Heifers (1-2yrs)      | 176.1±9.44  | 35  | 180.2±10.26 | 45  | 192.9±10.88 | 50  | 196.6±10.34 | 60  |
|       | Young males (1-2yrs)  | 169.3±8.17  | 5   | 162.9±22.49 | 5   | 158.4±21.55 | 9   | 161.1±14.60 | 14  |
|       | Calves (<1yr)         | 68.6±3.65   | 77  | 71.8±3.19   | 76  | 72.6±4.27   | 76  | 65.1±3.68   | 72  |
| LH2   | Female adults (>2yrs) | 254.2±4.56  | 140 | 252.9±4.13  | 136 | 265.9±3.97  | 135 | 267.9±4.11  | 129 |
|       | Male adults (>2yrs)   | 239.3±14.45 | 18  | 248.0±17.58 | 15  | 299.2±19.95 | 11  | 314.6±23.29 | 10  |
|       | Heifers (1-2yrs)      | 143.0±8.46  | 30  | 147.8±6.66  | 45  | 155.8±6.13  | 54  | 170.1±5.79  | 53  |
|       | Young males (1-2yrs)  | 115.0±7.12  | 11  | 130.2±7.32  | 11  | 137.6±5.95  | 12  | 151.5±6.55  | 13  |
|       | Calves (<1yr)         | 67.2±3.56   | 69  | 68.7±3.37   | 74  | 70.5±4.30   | 65  | 77.4±4.86   | 60  |
| LH3   | Female adults (>2yrs) | 266.4±8.02  | 74  | 266.0±8.51  | 65  | 270.6±9.33  | 64  | 266.8±9.21  | 65  |
|       | Male adults (>2yrs)   | 220.5±13.66 | 23  | 284.7±15.41 | 16  | 284.7±20.92 | 14  | 291.6±28.10 | 13  |
|       | Heifers (1-2yrs)      | 146.8±20.55 | 9   | 143.9±13.29 | 19  | 143.9±12.68 | 27  | 149.2±11.69 | 29  |
|       | Young males (1-2yrs)  | 120.9±8.91  | 12  | 125.4±9.76  | 11  | 125.4±10.81 | 12  | 133.0±10.85 | 13  |
|       | Calves (<1yr)         | 62.2±3.63   | 32  | 58.8±4.59   | 40  | 59.4±6.31   | 32  | 75.6±9.94   | 21  |
| UM1-4 | Female adults (>2yrs) | 263.2±5.08  | 103 | 268.1±5.20  | 103 | 275.7±5.81  | 94  | 272.9±5.98  | 92  |
|       | Male adults (>2yrs)   | 183.1±12.97 | 5   | 206.4±19.37 | 5   | 253.9±35.22 | 4   | 224.0±82.97 | 3   |
|       | Heifers (1-2yrs)      | 148.5±18.14 | 10  | 171.5±15.43 | 16  | 196.9±12.89 | 19  | 186.7±12.85 | 26  |
|       | Young males (1-2yrs)  | 130.9±13.64 | 12  | 132.2±11.04 | 15  | 139.6±8.90  | 15  | 138.7±8.98  | 20  |
|       | Calves (<1yr)         | 65.3±3.72   | 60  | 71.5±4.08   | 67  | 69.4±5.02   | 61  | 73.6±5.88   | 46  |
| Total | Female adults (>2yrs) | 275.7±3.12  | 461 | 277.0±3.12  | 440 | 285.5±3.22  | 418 | 284.3±3.31  | 406 |
|       | Male adults (>2yrs)   | 228.1±9.43  | 51  | 246.8±11.32 | 42  | 278.9±13.83 | 35  | 284.4±17.83 | 32  |
|       | Heifers (1-2yrs)      | 157.9±5.97  | 84  | 162.4±5.52  | 125 | 171.1±5.32  | 150 | 178.5±5.14  | 168 |
|       | Young males (1-2yrs)  | 128.3±6.13  | 40  | 132.5±5.57  | 45  | 138.9±5.24  | 56  | 145.9±5.09  | 65  |
|       | Calves (<1yr)         | 66.5±1.88   | 238 | 68.8±1.88   | 257 | 69.4±2.41   | 235 | 71.9±2.63   | 199 |

n = sample size; S1= season 1, S2= season 2, S3= season 3, S4, season 4.

Table 5
Average land size allocation for animal feed resource in Bomet.

| Feed type       | Average land size (ha) |
|-----------------|------------------------|
| Pasture         | 0.94                   |
| Napier          | 0.21                   |
| Rhodes          | 0.27                   |
| Maize*          | 0.54                   |
| Banana Pseudostems | 0.09               |
| Sweet potatoes  | 0.17                   |

* Maize is grown primarily for grain yield and animals benefit from the crop residue.
formed the highest proportion in the feed basket as shown together with the feed nitrogen content in Table 7 and gross energy in Table 8 of individual feedstuffs and the whole feed baskets in each of the agro-ecological zones across four periods of the year (otherwise referred here as seasons). A comprehensive dataset of feed basket information containing the different feedstuffs available in Bomet, the altitudes of the location of sampling, nutrient composition (i.e., nitrogen, acid detergent fibre, gross energy) of individual feedstuffs, and the dry matter digestibility of the feed-baskets grouped per AEZ are provided by [1]. These activity datasets were then used in calculations of the energy expenditure estimates i.e., metabolizable energy requirements (MER, MJ/day) for maintenance, growth (weight gain or loss), lactation, and locomotion for individual animals per household. All MERs were then summed up to estimate dry matter intake (DMI, kg/day) that was then used to estimate daily methane production (DMP, g/day) and ultimately emissions factors (EF) as shown by [1]. The estimated enteric methane EFs are presented in Table 9. Table 10 presents a comparison between the estimated EFs with the IPCC default values for Africa [2] and EFs from Nandi, Kenya [3], a region in close proximity to Bomet. The differences in EFs may be due to differences in live weights of all the animal classes, dry matter

Fig. 1. Mean live weight gains (g/day) for females and males (>2 years), heifers and young males (1-2 years), and calves (<1 year) in seasons 1, 2, 3, and 4 and four agro-ecological zones in Bomet.

Table 6
Pasture biomass yield (tonnes of dry matter (DM) per ha) ± standard error of means for the 4 agroecological zones in Bomet County across four seasons.

| Agro-ecological zones       | Season 1  | Season 2  | Season 3  | Season 4  |
|----------------------------|-----------|-----------|-----------|-----------|
| Lower Highland 1            | 2.20±0.225| 4.43±0.548| 3.91±0.682| 3.83±0.362|
| Lower Highland 2            | 1.05±0.114| 2.68±0.522| 1.61±0.195| 2.70±0.360|
| Lower Highland 3            | 1.49±0.154| 3.39±0.555| 2.74±0.656| 3.05±0.545|
| Upper Midlands 1-4          | 1.94±0.402| 3.38±0.749| 2.47±0.536| 3.92±0.367|
Table 7  
Feedstuff composing the feed-basket with their individual and cumulative feed nitrogen (g/100g).

| AEZ  | Feedstuff       | Season 1                      |       | Season 2                      |       | Season 3                      |       | Season 4                      |       |
|------|-----------------|-------------------------------|-------|-------------------------------|-------|-------------------------------|-------|-------------------------------|-------|
|      |                 | Proportion (%) Feed N (g/100 g DM) | Feed N Ration  (g/kg DM) | Proportion (%) Feed N (g/100 g DM) | Feed N Ration  (g/kg DM) | Proportion (%) Feed N (g/100 g DM) | Feed N Ration  (g/kg DM) | Proportion (%) Feed N (g/100 g DM) | Feed N Ration  (g/kg DM) |
| LH1  | Pasture         | 39.7                          | 2.44  | 9.68                          | 2.27  | 12.92                         | 2.42  | 15.66                         | 2.40  | 16.12                         |
|      | Napier          | 33.0                          | 2.40  | 7.92                          | 2.40  | 5.66                          | 2.40  | 7.27                          | 2.40  | 7.43                          |
|      | Rhodes grass    | 3.3                           | 0.96  | 0.32                          | 0.23  | 3.0                           | 0.96  | 0.29                          | 3.1   | 0.96                          |
|      | Maize Stover    | 22.8                          | 1.97  | 2.71                          | 1.19  | 1.94                          | na    | na                            | na    | na                            |
|      | Banana Pseudo stems | 1.0                        | 2.26  | 0.23                          | 1.0   | 0.23                          | 1.0   | 0.23                          | 1.0   | 0.23                          |
|      | Sweet potato vines | 1.0                        | 3.52  | 0.35                          | 1.0   | 0.35                          | 1.0   | 0.35                          | 1.0   | 0.35                          |
| Total |                 | 100.0                         | 21.20 | 100.0                         | 21.32 | 100.0                         | 21.80 | 100.0                         | 24.43 |
| LH2  | Pasture         | 31.3                          | 2.53  | 7.91                          | 1.94  | 10.43                         | 2.22  | 14.36                         | 75.4  | 2.08                          |
|      | Napier          | 21.0                          | 2.12  | 4.46                          | 2.12  | 3.00                          | 2.12  | 6.01                          | 19.7  | 2.12                          |
|      | Rhodes grass    | 4.6                           | 0.89  | 0.41                          | 0.27  | 6.2                           | 0.89  | 0.55                          | 4.3   | 0.89                          |
|      | Maize Stover    | 42.5                          | 1.39  | 5.91                          | 1.39  | 3.98                          | na    | na                            | na    | na                            |
|      | Banana Pseudo stems | 0.6                        | 2.79  | 0.17                          | 0.4   | 0.11                          | 0.8   | 0.23                          | 0.6   | 0.16                          |
| Total |                 | 100.0                         | 18.86 | 100.0                         | 17.79 | 100.0                         | 21.14 | 100.0                         | 20.41 |
| LH3  | Pasture         | 35.9                          | 2.65  | 9.51                          | 2.05  | 11.49                         | 2.48  | 17.62                         | 73.2  | 2.16                          |
|      | Napier          | 16.8                          | 2.24  | 3.77                          | 2.24  | 2.58                          | 2.24  | 4.34                          | 18.0  | 2.24                          |
|      | Rhodes grass    | 8.9                           | 0.82  | 0.73                          | 0.82  | 0.50                          | 0.82  | 0.78                          | 8.8   | 0.72                          |
|      | Maize Stover    | 38.4                          | 1.50  | 5.76                          | 1.50  | 3.95                          | na    | na                            | na    | na                            |
| Total |                 | 100.0                         | 19.77 | 100.0                         | 18.52 | 100.0                         | 22.75 | 100.0                         | 20.56 |
| UM1-4| Pasture         | 32.8                          | 2.65  | 8.69                          | 2.01  | 9.23                          | 2.01  | 16.51                         | 70.7  | 2.30                          |
|      | Napier          | 23.8                          | 1.80  | 4.28                          | 1.80  | 3.44                          | 1.80  | 6.05                          | 23.7  | 1.80                          |
|      | Rhodes grass    | 4.8                           | 0.85  | 0.41                          | 0.85  | 0.33                          | 0.85  | 0.57                          | 5.1   | 0.85                          |
|      | Maize Stover    | 38.2                          | 1.28  | 4.89                          | 1.28  | 3.93                          | na    | na                            | na    | na                            |
|      | Banana Pseudo stems | 1.0                        | 2.16  | 0.22                          | 2.16  | 0.22                          | 2.16  | 0.22                          | 2.16  | 0.22                          |
| Total |                 | 100.0                         | 18.47 | 100.0                         | 17.15 | 100.0                         | 23.35 | 100.0                         | 21.17 |

na= not applicable.
Table 8
Feedstuff composing the feed-basket with their individual and cumulative gross energy (MJ/kg DM).

| AEZ  | Feedstuff          | Season 1 | Season 2 | Season 3 | Season 4 | Season 5 |
|------|--------------------|----------|----------|----------|----------|----------|
|      |                    | Proportion (%) | GE (MJ/kg DM) | Proportion (%) | GE (MJ/kg DM) | Proportion (%) | GE (MJ/kg DM) | Proportion (%) | GE (MJ/kg DM) | Proportion (%) | GE (MJ/kg DM) |
| LH1  | Pasture            | 39.7      | 6.84     | 56.9      | 9.68      | 64.7      | 11.00     | 64.7      | 11.00     | 64.7      | 11.00     |
|      | Napier             | 33.0      | 5.31     | 23.6      | 3.79      | 30.3      | 4.87      | 31.0      | 4.98      | 3.1       | 0.56      |
|      | Rhodes grass       | 3.3       | 0.60     | 2.4       | 0.43      | 3.0       | 0.55      | 3.1       | 0.56      | 3.1       | 0.56      |
|      | Maize Stover       | 22.8      | 3.88     | 16.3      | 2.77      | na        | -         | na        | -         | na        | -         |
|      | Banana Pseudo stems| 1.0       | 0.19     | 1.0       | 0.19      | 1.0       | 0.19      | 1.0       | 0.19      | 1.0       | 0.19      |
|      | Sweet potato vines | 1.0       | 0.16     | 1.0       | 0.16      | 1.0       | 0.16      | 1.0       | 0.16      | 1.0       | 0.16      |
| Total|                    | 100.0     | 16.98    | 100.0     | 17.02     | 100.1     | 16.78     | 100.0     | 17.08     | 100.0     | 17.01     |
| LH2  | Pasture            | 31.3      | 5.25     | 53.8      | 9.19      | 64.7      | 11.15     | 75.4      | 17.16     | 12.94     |
|      | Napier             | 21.0      | 3.42     | 14.2      | 2.30      | 28.4      | 4.61      | 19.7      | 16.27     | 3.21      |
|      | Rhodes grass       | 4.6       | 0.80     | 3.1       | 0.54      | 6.2       | 1.08      | 4.3       | 17.57     | 0.75      |
|      | Maize Stover       | 42.5      | 7.40     | 28.6      | 4.98      | na        | -         | na        | -         | -         |
|      | Banana Pseudo stems| 0.6       | 0.11     | 0.4       | 0.07      | 0.8       | 0.14      | 0.6       | 17.91     | 0.10      |
| Total|                    | 100.0     | 16.98    | 100.0     | 17.08     | 100.0     | 16.99     | 100.0     | 17.01     | -         |
| LH3  | Pasture            | 35.9      | 6.21     | 56.1      | 9.66      | 71.1      | 12.44     | 73.2      | 17.22     | 12.61     |
|      | Napier             | 16.8      | 2.76     | 11.5      | 1.89      | 19.4      | 3.18      | 18.0      | 16.41     | 2.95      |
|      | Rhodes grass       | 8.9       | 1.55     | 6.1       | 1.06      | 9.5       | 1.67      | 8.8       | 17.46     | 1.54      |
|      | Maize Stover       | 38.4      | 6.68     | 26.3      | 4.58      | na        | -         | na        | -         | -         |
| Total|                    | 100.0     | 17.21    | 100.0     | 17.19     | 100.0     | 17.09     | 100.0     | 17.10     | -         |
| UM1-4| Pasture            | 32.8      | 5.72     | 45.9      | 7.84      | 59.0      | 10.30     | 70.7      | 17.01     | 12.02     |
|      | Napier             | 23.8      | 3.88     | 19.1      | 3.12      | 33.6      | 5.47      | 23.7      | 16.30     | 3.86      |
|      | Rhodes grass       | 4.8       | 0.86     | 3.8       | 0.69      | 6.7       | 1.21      | 5.1       | 17.95     | 0.91      |
|      | Maize Stover       | 38.2      | 6.77     | 36.7      | 5.44      | na        | -         | na        | -         | -         |
|      | Banana Pseudo stems| 1.0       | 0.18     | 1.0       | 0.18      | 1.0       | 0.18      | 1.0       | 0.18      | 1.0       | 0.18      |
| Total|                    | 100.0     | 17.40    | 100.0     | 17.27     | 100.0     | 17.16     | 100.0     | 17.08     | -         |

na= not applicable, "-" represents no data.
Table 9
Live weight (mean ± standard error of means, LW kg) and emission factors (mean ± standard error of the mean, Kg CH₄/head/year) for females and males (>2yrs), heifers and young males (1-2yrs) and calves (<1yr) in four agro-ecological zones in Bomet.

| AEZ     | Females (>2yrs) | Males (>2yrs) | Heifers (1-2yrs) | Young males (1-2yrs) | Calves (<1yr) |
|---------|-----------------|---------------|------------------|----------------------|--------------|
|         | Mean LW (kg)    | EF (kg CH₄/ head/yr.) | Mean LW (kg)    | EF (kg CH₄/ head/yr.) | Mean LW (kg) |
| LH1     | 316.4±0.14      | 58.8±2.10      | 249.3±1.23       | 34.2±5.43            | 186.5±0.30   |
| LH2     | 260.2±0.11      | 44.3±1.25      | 275.3±1.87       | 38.4±2.99            | 154.2±0.60   |
| LH3     | 267.4±0.31      | 42.8±2.11      | 264.7±3.25       | 36.9±3.52            | 146.7±2.03   |
| UM 1-4  | 270.0±0.22      | 51.6±1.82      | 216.8±15.82      | 39.1±7.74            | 176.9±1.34   |
| All Bomet | 280.6±0.05    | 50.1±0.98      | 259.5±1.83       | 37.1±2.09            | 167.5±0.18   |
Table 10: Comparison between Intergovernmental Panel on Climate Change default values for grazing systems in Africa, estimated values from Nandi study and Bomet, Kenya for enteric methane emission factors (EF, kg CH₄/ha-day/year) and average live weight (LW, kg) for females and males (>2 years), heifers and young males (1–2 years) and calves (<1 year).

| Cattle category | IPCC [2] default values (kg) | Nandi Study [3] (kg) | Present study (Bomet) (kg) |
|-----------------|-----------------------------|----------------------|---------------------------|
| Females (>2 years) | 275 67 | 307 47.8 | 280.6 50.1 |
| Males (>2 years) | 340 67 | 266 37.2 | 259.5 37.1 |
| Heifers (1–2 years) | 204 46 | 187 28.5 | 167.5 28.3 |
| Young males (1–2 years) | 204 46 | 157 27.2 | 136.5 26.4 |
| Calves (<1 year) | 82 31 | 73 25.8 | 69.3 18.3 |

digestibility for Bomet as reported by [4], and methane conversion factor ($Y_m$). Nandi’s study and the present study both used the same $Y_m$ which was 10% higher than IPCC. The activity data was collected at 3 months intervals and the periods identified as seasons 1, 2, 3, and 4 and described below and the MERs, DMI, and DMP were also calculated per season.

- Season 1: 01/12/2016 to 28/02/2017 – Partly wet, warm, and dry
- Season 2: 01/03/2017 to 31/05/2017 – Cold and wet
- Season 3: 01/06/2017 to 31/08/2017 – Cold and dry
- Season 4: 01/09/2017 to 31/11/2017 – Warm, dry, and partly wet

2. Experimental Design, Materials and Methods

Bomet (Latitude: 0°48′00″ N, Longitude: 35°13′59.88″ E) is located in the western part of Kenya [6] occupying an area of 2,037km². Smallholder farms were selected using a sampling protocol described by [3]. Farms were visited 9 times in 12 months between December 2016 and January 2018 at an interval of 1.5 months. Animals were weighed at 0, 3, 6, 9, and 12th months using a cattle weight scale. Age of adult animals was determined using dentition while that of young cattle and parity was obtained from farmer recalled. Milk yield was recorded daily using uniform Mazzican (http://www.mazzican.com) provided to each farm and samples collected at 1.5, 4.5, 7.5, and 9th month for butterfat analysis using Gerber method, conducted in a local milk factory. Pasture biomass was determined by using exclusion cages set at grazing paddocks and grass was harvested at 3, 6, 9, and 12 months. Feed samples were collected at the first three months of the project, dried at 50°C, and analyzed for dry matter (DM), nitrogen (N) content using the Kjeldahl method [7], and gross energy (GE) using a bomb calorimeter. Feed N and GE of the feed baskets were determined using an existing procedure to estimate the proportional contribution of different feedstuff to the overall feed basket [8].

The data were grouped into seasons (S1, S2, S3, and S4), AEZs (lower highland 1, 2, 3 (LH1, LH2, LH3) and upper midlands 1–4, (UM1–4)) and age groups of females and males >2years, heifers and young males 1-2years and calves <1year. This information was used to estimate MER for maintenance, growth, lactation, and travel based on equations from [9] and then summed up to obtain the total MER. Finally, using total MER, dry matter digestibility (DMD) [8], and GE of feed, DMI was estimated (see Eq. 1) and used to estimate the DMP using [10] prediction equation (Eq. 2):

$$ DMI \ (kg/day) = \frac{MER_{\text{Total}} (MJ/day)/[GE \ (MJ/kg \ DM) \ast (DMD/100)]}{0.81} \quad (1) $$

$$ DMP \ (g/day) = 20.7 \ast DMI \ (kg/day) \quad (2) $$
Ethics Statement

All animal data used in this study were collected as part of standard farming practices. As such, no part of this research was subject to the approval of an ethics committee.

CRediT Author Statement

**Phyllis Ndung’u**: Data analysis and interpretation, drafting the paper, critical revision of the paper; **Peter Kirui**: Data Collection; **Taro Takahashi**: Data interpretation, critical review of the paper, final approval of the version to be published; **Cornelius Jacobs Lindeque Du Toit**: Critical review of the paper; **Lutz Merbold**: Critical review of the paper; **John Goopy**: Conceptualizing and designing of the study, data interpretation, drafting of the paper, critical review of the paper, final approval of the version to be published.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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