

Manual for Using the MSU Greenhouse Gas (GHG) Calculator for Sheep Operations

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General information

The MSU GHG calculator uses equations from the Intergovernmental Panel on Climate Change guidelines (2019 refinements to Chapters 10-11) for GHG emissions estimation.

To get the most accurate estimate for your farm, use the average values over the last 3 years of records, excluding any years with major outlying factors, such as drought, disease outbreak, or significant marketing changes. The calculator is intended for farms with stable animal numbers, not increasing or decreasing in flock size.

Which calculator should I use?

There are two different Excel files that can be used to estimate GHG emissions from your operation. The “Intensive” worksheet is most suited for operations that have harvested forages and housed animals, with number of animals and diet quality/type relatively consistent throughout the year. Animals are fed and housed based on production stage rather than influenced by seasonal changes in forage quality and availability. The “Range” worksheet is most suited for operations that mainly graze animals and whose animal numbers may fluctuate throughout the year or by season. It applies to Western range operations as well as those who heavily graze their animals regardless of location. The forage quality and availability are influenced by season rather than by production stage and can be expressed specific to each month rather than consistent throughout each production stage.

Basic worksheet:

Please enter information into the bold or dark yellow cells. Many cells have comments with a description of what is being asked (you can hover over the red triangle to view the comment). If you do not have anything to report in a cell, leave it blank (for example, if you don’t use terminal rams or don’t purchase any ewe lamb replacements, do not enter anything into those cells).

Diet worksheet:

Intensive farms - For breeding ewes (both mature and ewe lambs), there are 3 separate production stages – maintenance (not pregnant or lactating), pregnancy, and lactation. Each stage has two parts (1 and 2). The second part is used if either the housing or diet changes during that production stage. For instance, if maintenance ewes are kept on flat pasture then brought onto a bedded pack for 30 days, you would select “flat grazing” for part 1 of maintenance and “bedded pack” for part 2. (The order does not matter, it is simply splitting up each production stage into multiple parts if the diet and/or housing changes.) Then put in 30 days for the number of days in part 2 (the bold yellow cell), which will automatically fill out the remaining days of maintenance in part 1 (a blue cell, which means you don’t put values here; it automatically fills in the rest of days during

maintenance). Do the same for rams. Remember, you can see further, specific explanations in the red notes throughout the worksheet as needed.

Range farms – In row 4, please enter the monthly inventory of ewes that successfully produce lambs each year (or each lambing cycle). Since your operation may buy and sell productive ewes, enter the number on-farm during each month of the year. In row 5, enter the monthly number of ewes who are not productive (not lambing) each year (or lambing cycle). This can also be done by multiplying the total monthly number of breeding ewes by the average lambing rate. For example, if 91% of ewes lamb out of 100 ewes, row 4 would be 91 and row 5 would be 9 until the total number of breeding ewes changes from 100. In row 8, select which production stage the ewes are in during that month. In row 9, select the most appropriate type of housing during that month. Please enter the monthly numbers for ewe lambs (first lambing season ewes) in rows 6 and 7, similar to mature ewes in rows 4 and 5. A ewe lamb remains one for its first breeding year (essentially there would be ewe lambs present at all times since some enter at first breeding then exit one year later). Also, enter both terminal and maternal monthly breeding ram numbers (both mature and first year breeding rams) in rows 10 and 11, along with their production stage and housing type in rows 12 and 13.

The remaining instructions are the same for both Intensive and Range farms.

The diet type (for each production stage on an Intensive farm, or for each month on a Range farm) is a drop-down menu, with various diets presented as options and a default TDN and CP value associated with each option. The animal's intake and subsequent emissions are determined by the diet quality, so please enter values that are accurate to the farm if available. You may change the default values for any diet option in columns M and N if the diet quality is consistent for that option on your operation. This will save time rather than doing it each time it is selected.

The calculator allows for up to three different groups of market lambs to be sold (i.e. different age, weight, diet, and/or housing per group; see comments within the worksheets). It also considers ewe and ram replacements, separating those kept on-farm versus those sold as breeding stock. For market and replacement lambs, the beginning body weight (BW) is already assigned from the Basic worksheet records as the weight at weaning or purchase, and the final BW is already assigned as the BW of the last housing/diet option (column) at either sale or first breeding. Fill in the approximate body weight when the lambs switch housing and/or diet as well as how many days they on each housing/diet combination. There are 3 potential parts (diet and housing combinations) between weaning (beginning BW already entered in the top left cell of part 1) and either sale or breeding (ending BW already entered in the bottom right cell of part 3). All bold yellow cells must be filled in on part 1 (first column), and if there is a second diet/housing combination, all bold yellow cells must be filled in on any additional columns used (either all bold yellow cells filled out in each column or none of them).

Example: for the first group of market lambs (1), if they stay on the same housing and diet the whole time, then simply enter in the sale weight already shown in D23 (it was entered in the Basic worksheet) into B23. The number of days until sold is also calculated from the Basic worksheet and appears in cell B24. If the market lambs are put on a different diet and/or moved to a different housing type, please enter the BW when they change in B23 and the final sale BW is now put into C23. Then, enter the number of days in that second housing/diet combination in C24 (it will

automatically fill in B24 with a new number of days). Select the most appropriate housing situation and diet quality for each part (column), and the TDN and CP (light yellow cells) can be modified to fit the situation. The market lamb format is also used for replacements in rows 31-62 below.

Under the diet/housing information are some calculations made from the “Basic” input sheet. You can review these values to double check the previously entered values, but do not modify them directly in this area. Only enter records into the bold and light yellow cells.

Purchases worksheet:

Input the amount of each item that enters the farm (purchased or not) and is used only for sheep production. If something has another use, such as beef cattle or cash crops, please enter only the amount that is used for sheep. If on a multispecies operation and unsure what amount is used only for sheep production, you can divide the total amount purchased by the % of total animal units (AU) that are sheep. For example, a cow is 1 AU, a ewe is 0.2 AU, and a ewe/lamb pair is 0.3 AU. If you use 100 gallons of diesel on a farm with 10 cows and 40 ewe/lamb pairs, this is $10 + 40 \times 0.3 = 22$ AU total. Since 12 AU are sheep and 10 AU are cows, $12/22 \times 100\% = 55\%$ sheep. So out of 100 gallons used per year, $100 \times 55/100\% = 55$ gallons are used for the sheep each year.

Columns D and E contain default values for the number of miles each item travels from its source to your farm via light truck (perhaps between warehouse/processor/etc and local coops/mills/etc) and heavy duty truck (perhaps between point of origin and warehouse/processor/etc). If you know the actual value, please enter it instead. For instance, if your California farm uses Iowa corn, it travels longer than the default value of 500 miles via heavy truck.

At the bottom of the sheet is Contract transportation (rows 59-62). These are miles transporting sheep off-farm, to the farm, or between locations (but not after sale, as emissions accounting stops at the farm gate in this model). This gas/diesel use is not included in rows 56-57 above (those gallons are for gas/diesel that you brought on farm and used anywhere for sheep production, i.e. pickups, tractors, ATVs). Please enter the number of miles these contracted trucks travel and their estimated miles per gallon. Rows 64-68 allow you to change the default hauling capacity and miles/gallon of the light and heavy duty trucks used for all items listed above.

Crops worksheet:

Nitrous oxide (N_2O) is released via decomposing crop residue and also from changes in soil organic matter (called soil mineralization). To account for these changes, the Crops worksheet has space to record the acres of land where these things occur. This is any land that has **annual** crops (which leave a residue above and below ground that decomposes each year) or **terminated** crops (such as terminating a crop before establishing another or during pasture renewal).

There is space for up to 6 “fields”. These are plots of land that have the same management (same crops grown and similar harvesting/grazing). Please enter the number of total acres (if on separate plots of land but the same management, you can combine these acres), pick the most applicable species grown from the dropdown list, and an estimated amount of dry matter that is present at the end of the growing season or at termination, before and after it’s harvested or grazed (final harvest or grazing bout). The dry matter left (the difference between the amount present and the amount harvested) will be considered “crop residue” which will decompose above and below ground and

release N₂O. If it is perennial crop, please enter the number of years it is grown before terminated in row 11, as the residual N will be averaged on a yearly basis.

The amount of carbon sequestered each year is estimated via soil sampling results entered into rows 7-10. If you have values for soil organic matter (SOM, as % SOM) and know the approximate change over the last few years (for example, a field going from 3.0% SOM to 3.5% SOM over 10 years would be 0.5%/10 = 0.05% per year) please enter them in rows 7 and 8. If your records are in terms of % C instead of SOM, you can multiply that value by 0.58 to get it in units of % SOM (since SOM is 58% carbon; example of 3.0% SOM would be 3.0*0.58 = 1.7% C). Enter the average soil density for each field in row 9 and the depth of sample taken (default of 15 cm, this value will reflect the depth over which the SOM or C is changing). The total amount of C sequestered due to these changes in SOM among all entered fields is calculated in cell B14.

The N₂O emitted from purchased nitrogen fertilizers (remember, only fertilizer that is applied on land for **sheep** production should be entered in the Purchases worksheet) is included in rows 17-20, assuming all of it is applied yearly on average.

TotalGHG worksheet:

Please enter the results for CO₂, N₂O, and CH₄ from COMET-Planner in rows 29-31. These are the estimated carbon sequestration and emissions reductions (or increases if the value is negative) after the anticipated management changes entered into COMET-Planner. These values are then included with the sheep, purchases, and crops emissions estimated in this calculator.

The pie chart to the right presents the percentage of total CO₂e emissions that are emitted by each source (enteric CH₄, manure, etc) listed in rows 6-25.

Rows 28-33 present the amount of either CO₂e or C either sequestered or whose emissions were reduced by soil/crop management (see column headings). Column E presents this information per ton of C across the entire flock annually. Cell E32 is the amount of sequestered or reduced tons of C per year on the operation via crop/soil management in **COMET Planner**. Cell E33 is the amount of sequestered C per year on the operation via management on the **Crops worksheet**.

Row 36 is the total amount of CO₂e emitted per year by the sheep, purchases, and crops (Column C), and row 37 includes crop/soil management changes (from COMET Planner and Crops worksheet). Row 38 shows the % of total farm CO₂e emissions that are mitigated (sequestered C or reduced GHG emissions) by crop/soil management. These values are also depicted in the graph on the right hand side (green histogram).

Rows 53-58 allocate the CO₂e emissions to product (lamb or all sheep sold) at the farm gate. These allocation values are commonly used to compare the environmental footprint of a product. Besides lamb or sheep liveweight (LW or BW), other potential comparison values would be kgCO₂e per kg of carcass weight or per kg of consumed meat or protein, depending on the type of comparison being made. Row 57 shows the kg of CO₂e emitted per kg of lamb liveweight (LW) sold each year (market lambs and replacements), and row 58 shows per kg of all sheep sold (cull ewes and rams included). The values in Column C **do not** include crop/soil management results (COMET-Planner and Crop worksheet records) while those in Column D **do** include them. Currently, IPCC (Intergovernmental Panel on Climate Change) guidelines on carbon footprints do not include carbon sequestration;

therefore, Column C contains the values that would be reported. However, for the purpose of understanding the role of crop/soil management and aspiring to improve carbon balance via these practices, it is included for reference in Column D.

Rows 65-69 show the operation's GHG emissions divided into the three major greenhouse gases (Column D is % of total CO₂e emissions by each of the 3 GHGs). The pie chart to the right presents these estimates graphically.

Starting at row 95 is a one-page summary of the results. You may print this out (page 3 of the worksheet) for your records or to easily compare alternative management scenarios.