**THE FOOD SYSTEM MODEL**

*The Drawdown Food System model is designed to understand the impacts of two Drawdown solutions: plant-rich diet and reduced food waste. Running this ‘combined’ model will present results for both solutions implemented individually AND their combined impact when implemented together, including the appropriate allocation of emissions savings to each solution. The “Process” document is a guide to (1) understanding the several spreadsheets that together comprise the Food System model, and aims to provide the instructions necessary to (2) run, and (3) update the model as necessary in the future. The complementary “Methods” document is intended to explain the assumptions and provide the necessary derivations to understand the “Why”s behind the spreadsheets’ technical decisions. These two documents along with the intra-spreadsheet comments and notations, are intended to provide sufficient guidance to future fellows and analysts working with the Food System analysis—but it is complicated, so one shouldn’t hesitate to ask questions.*

**OVERALL MODEL STRUCTURE**

* In the updated/integrated Food System model, three ‘inputs’ spreadsheets (***POPULATION inputs***, ***LCA inputs***, and ***FOOD inputs***) feed into the ***CORE*** spreadsheet, whose results inform three output spreadsheets for ***EMISSIONS and*** ***YIELD***, and ***WASTE***.
* The ***POPULATION inputs*** spreadsheet contains the population estimates that comprise the REF1 and REF2 population scenarios, as well as a lookup table that enables the model results to be summarized by region according to various typologies.
* The ***LCA inputs*** spreadsheet converts results from selected food commodity LCA meta-studies into a database of LCA impacts (g CO2e/kcal) by FAO commodity. This spreadsheet’s results are pasted into the ***EMISSIONS and YIELD*** spreadsheet and will only need to be updated when new LCA studies and/or meta-studies are introduced to the Food System model.
* The ***FOOD inputs*** spreadsheet contains several key model inputs, for including the definition of the “plant-rich” diet, food demand forecast parameters, food waste factors at various stages of the food life cycle, a lookup table for FAO commodities to be grouped according to various typologies, a table with more detailed information about FAO commodities, and the raw foundational food supply estimate data from the UN FAO. The ***FOOD inputs*** spreadsheet is also itself a submodel, as it generates the three REF scenario values (in kcal/capita/day) for food demand, waste, and supply, as well as the Plant-rich demand (in kcal/capita/day) for each given country and FAO commodity (REF\_demand, REF\_waste, REF\_supply, and plantrich\_demand, respectively).
* The ***CORE*** spreadsheet takes the REF scenario and the PDS adoption parameters for both diet and waste (in particular, total adoption and adoption start/end years), and uses those inputs to generate the PDS scenario values (in kcal/capita/day) for food demand, waste, and supply, for each given country and FAO commodity.
* The ***EMISSIONS and YIELD*** spreadsheet then takes the PDS and REF scenario supply values and estimates the total emissions in both scenarios by country. It also generates global food yields as inputs for the land use yield model, according to the categories used in the yield model.
* The ***WASTE*** spreadsheet takes in REF and PDS waste values (per capita, per day) by country and commodity, then converts those into annual tonnage “waste fractions” by country, food waste category, and food waste life cycle stage, for use beyond the Food System model in the Drawdown waste modeling system.
* The ***RESULTS***spreadsheet does not have its own infrastructure/calculations, but rather serves as a repository for results from the other tabs. In contrast to the rather cumbersome spreadsheets in which the Food System model’s core calculations are made, the ***RESULTS*** spreadsheet is designed to be a relatively small file with little-to-no active formulae to manipulate easily once the model update process is complete.

**EXCEL KEY (and tips)**

Tabs:

* *Tabs are organized from L to R in [approximate; not always strictly linear] order of operations. This should help new users more intuitively understand the model structure and apparently helps with overall calculation speed.*
* **Blue tabs** = raw and adapted source data, including lookup tables (which may need to be updated, but less frequently)
* **Tan tabs** = data in these tabs should be pasted from other sheets
* **Light green tabs** = data in these tabs are used as inputs (‘to be copied’) in other Food System spreadsheets
* **Dark green tabs** = model inputs (parameters and assumptions) and model outputs/results
* **Grey tabs** = reference information/intermediate calculations
* **Purple tabs** = summary calculations that are not necessary for model runs but will likely be useful in presenting and interpreting model results

Cells

* **Orange cells** = headers describing below data/information
* **Tan cells** = data to be copied or pasted-into, and cells with instructions RE copy-pasting data (when filled with bold red text)
* **Light green cells** = input parameters, to be changed by user according to relevant instructions
* **Blue cells** = headers and/or metadata

A few notes/recommendations for interacting with the model itself:

* Turn Automatic calculation off and enable ‘Manual’ calculation instead
* Avoid using the “cut” and “insert” functions to the extent possible, which work very slowly in big spreadsheets
* When a calculation in the model breaks and the reason is not immediately apparent, try using the “Evaluate formula” process to step through calculations in order to understand what’s broken
* Across the model spreadsheets, files have been saved with all but the first row of large data tables copied and pasted as “Values Only”—meaning that data are stored as text rather than formulas. This has the benefit of allowing users to open and navigate through each spreadsheet much more quickly, but the cost of requiring the user to be mindful of refreshing formulae throughout each data table, which requires particular care in the several cases in which a single tab contains multiple data tables.

**FOOD SYSTEM MODEL GUIDE**

For each of the spreadsheets that together comprise the updated Food System model, the next section provides information akin to meta-data about the Drawdown Food System model:

* A high-level description of the data/analysis included in every tab of each spreadsheet
* Descriptions—preceded by highlighted text—of:

1. How to update data in that tab, if/when necessary, and
2. Which updates may be necessary in the model at large because of those updates

These explanations are then followed by a step-by-step process for re-running the Food System model with a new scenario in which no updates are required to the datasets upon which the model relies.

***POPULATION inputs***

The ***FOOD*** and ***CORE*** spreadsheets generate the demand, supply, and waste forecasts on a per-capita basis, so population data are not used in these models. Population data are accounted for later when calculating country-level and global waste, emissions, and yield estimates for both the REF and PDS scenarios.

The “pop\_REF1” tab reflects the “High Population” forecast used as the reference case in Project Drawdown; the “pop\_REF2” tab reflects the “Medium Population” forecast, which is equivalent to the post–family planning intervention population forecast. These two population scenarios are used to calculate the difference in Food System emissions in Drawdown’s Integrated Model that are attributable to family planning.

Population data used in the Food System model have been drawn from the *UN World Population Prospects*. To update the population data in the Food System model:

* Open the ***Food System POPULATION inputs*** spreadsheet and make changes accordingly in both the “pop\_REF1” and “pop\_REF2” tabs. The values in tan are the raw population estimates by country and year from 2015-2060. Data in this spreadsheet are the ‘true’ data in the Food System model, and should be copied and pasted to replace population data throughout the rest of the model. As such, the user should take care to make sure that any new or updated data sources use the same country names, spellings, etc., since various lookup-based excel formulas will depend on these spellings.
* Population data will need to be copied from the ***POPULATION inputs*** spreadsheet to both the **WASTE** and **EMISSIONS and YIELD** spreadsheets. Find the “pop\_REF1” and “pop\_REF2” tabs). Sort both tables by country name and then copy and paste the tan values from the “pop\_REF1” and “pop\_REF2” tabs into their corresponding tabs in the ***Food System EMISSIONS*** spreadsheet. If the country list itself has changed then the entire contents of the destination tables should be replaced.

The “country\_lookup” tab is a reference to determine which regions each country belongs to. Within the Food System model, various data sources provide estimates that vary regionally, but without consistent definition of regions. For example, some data apply only to the European Union, while others treat OECD90 as a block, one which includes Japan, which is in turn included in “Industrialized Asia” under a different regional typology. The “country\_lookup” table allows the Food System model to estimate the impacts of relevant input data to regions but at the country level, so that those impacts can be accounted for when emissions data are later summarized by IPCC (or Drawdown) region.

If any changes to the country lookup table are required, care must be taken to carry those updates throughout the model, with the following as guidelines:

* The ‘true’ data are housed in this ***POPULATION inputs*** spreadsheet, and should be edited and updated there.
* These data should then be copied and pasted into tabs with the same name in the ***FOOD inputs***, ***CORE***, ***WASTE*** and ***EMISSIONS and YIELD*** spreadsheets. If the country list has changed, or if a grouping category has been added or removed, then the entire contents of the destination tables should be replaced.
* The more burdensome part of this update process will be that many columns located throughout the Food System model have been generated by simple VLOOKUP formulas and then converted to static data (by pasting ‘values’ only). These data columns will need to be updated to ensure that model results remain accurate.
  + In the ***FOOD inputs*** spreadsheet:
    - *If the list of ‘waste regions’ changes, the “Waste\_forecast” tab will also need to be updated structurally such that the ‘Waste lookup’ column contains an exhaustive list of ‘Waste lookup’ values. This will then need to be updated throughout the Food System model*
    - *REF\_supply*: Current, Demand region, Waste lookup
    - *REF\_waste*: Waste lookup, as per *PDS\_waste and PDS\_supply* entry in ***CORE*** spreadsheet notes above
    - *REF\_demand*: Demand region
    - *Plant-rich\_demand*: Diet region
  + In the ***CORE*** spreadsheet:
    - *Plant-rich\_demand*: Diet region
    - *REF\_demand*: Diet region
    - *PDS\_waste and PDS\_supply*: ‘Waste lookup’ values will need to be updated if waste regions have changed, which will require adding columns for both ‘waste region #’ and ‘waste category’ and using CONCATENATE to combine them for each row containing a unique country-FAO commodity pair.
  + In the ***EMISSIONS and YIELD*** spreadsheet:
    - *REF\_country\_CO2*: IPCC (in both tables)
    - *PDS\_country\_CO2*: IPCC (in all three tables)
  + In the ***WASTE*** spreadsheet:
    - *REF\_waste*: Waste lookup (in both tables), Waste region (right-hand table, with data in g/cap-day)
    - *DIET\_waste*: Waste lookup (in both tables)
    - *WASTE\_waste*: Waste lookup (in both tables)
    - *PDS\_waste*: Waste lookup (in both tables)
    - *REF1\_fraction*: Waste region, Waste lookup, IPCC
    - *REF2\_fraction*: Waste region, Waste lookup, IPCC
    - *DIET\_fraction*: Waste region, Waste lookup, IPCC
    - *WASTE\_fraction*: Waste region, Waste lookup, IPCC
    - *PDS\_fraction*: Waste region, Waste lookup, IPCC

***LCA inputs***

Results from each life cycle analysis (LCA) review study are included in separate tabs, copied from their respective data tables or in some cases downloaded directly as materials published alongside relevant papers. Average, minimum, and maximum LCA values are included to provide an estimation range for emissions forecasts (for more details on estimation methodologies see Plant-Rich Diet Technical Report).

* These various studies (five, as of Sept 2018) are summarized in the “LCA Range” tab, with methods explained in column header comments and in the Technical Report.
  + Updating the inputs from these studies with new studies will be somewhat involved—in the current framework, food item LCA results are taken from whichever study or studies are deemed most credible. This generates a ‘hierarchy’ of LCA studies, which will need to be updated with any additional LCA results—this will not be trivial to change (though implementing such a change in the rest of the model will be straightforward, since LCA values are only applied in the ***EMISSIONS and YIELD*** spreadsheet).

To change LCA data or add new sources to the Food System model:

* The analyst may start by creating a new tab for each additional source. After reviewing existing sources, their methodologies, and cross-referencing the food commodity lists from each, the analyst should determine which sources are to be used and relied upon for which foods. Based on this determination, a formalized prioritization should be developed for which sources to use for which foods, and translated into an Excel framework. Depending on how consistent the hierarchy of sources is (i.e., is one source always considered superior to the others?) – or put a different way, how well the hierarchy lends itself to programmatic implementation in Excel – this update process may be more or less straightforward.
  + *When an update is necessary, more care could be taken to standardize the format of these sheets—for example, including and populating min/avg/max columns in each study tab before aggregating them, adding a column for “FAO commodity” lookup (to explicitly map ‘source’ food categories to Food System model food categories, and (perhaps? Just an idea…) adding columns that indicate the source’s relative credibility*

To update values within the model:

* In the tabs with the same name (“LCA Range”) in both the ***LCA inputs*** and ***EMISSIONS and YIELD*** spreadsheets, sort both tables by ‘sort code’ (this sort order is a little odd, as it is not alphabetical, which is just an artefact of a clunky original model design), then copy and paste (only VALUES) the tan-highlighted values from the ***LCA inputs*** spreadsheet into the ***EMISSIONS and YIELD*** spreadsheet.

***FOOD inputs***

* The “FAO commodity details” tab is included for reference purposes only
* The “FAO20XX” tabs include the core ‘food supply’ source data (from 2010-2013, as of Sept 2018) from the Food and Agriculture Organization of the United Nations (FAO). In each tab, these FAO data for all FAO food commodities are pasted in their raw form, with values in kcal/cap/day.
* To update the base FAO data in the ***FOOD inputs*** spreadsheet, one must add new tabs and make adjustments to the REF\_xx tabs:
  + When available, more recent years’ data should be added in additional tabs in the same format.
  + Once added, formulas in the “REF\_supply” tab will need to be updated for years 2014 and 2015 (when 2015 data are available, additional changes will need to be made to “REF\_demand” and “REF\_waste” tabs as well, to shift the entire forecast back in time appropriately. See *Food System Model Methodology* for more details). The analyst should consult with senior Drawdown research team members to determine how to implement these changes. Current practice is to estimate the first year of “REF\_supply” data \*without\* a raw data input by averaging the previous three years, then to apply relative growth/change forecasts starting from the following year (i.e., as of Sept 2018, the year 2014 is estimated as the average of 2011, 2012, and 2013 raw data. 2015 is forecast based on Alexandratos et al. (2012)–derived growth rates, and every subsequent year is the sum of “REF\_demand” and “REF\_waste” values).
  + Each year of FAO data has a different length, because different countries report data for different lists of FAO commodities each year. For this reason, the “final” list of countries and FAO commodities used throughout the Food System model has a different number of FAO commodity entries for each country. When a new year of data is added, this “final” list could change, requiring changes to tables throughout the Food System model. When this is required, a judgment must be made RE whether it is more important to (1) preserve a slightly reduced calculation time by only including rows in the “final” list when a country has reported values for a specific FAO commodity—in which case, a new “final” list can be generated by copying and pasting the ‘country’ and ‘FAO commodity’ columns from each year of data actively used in the Food System model (e.g., as of Sept 2018 this would be the years 2011-2013) and then sorting it so as to eliminate duplicate values, or (2) add some calculation time but make the list comprehensive, which would require generating a new “final” list that included a row of data for every possible country–FAO commodity pair.
  + This new “final” list will have to be copied and pasted into all REF\_demand, REF\_supply, REF\_waste (including the second, mass-based table in the ***WASTE*** spreadsheet), PDS\_demand, PDS\_supply (including the second, “plant-rich only” supply table in the ***CORE*** and ***EMISSIONS and YIELD*** spreadsheets), PDS\_waste (including the second, mass-based table in the ***WASTE*** spreadsheet), Plant-rich\_demand, REF\_emissions, and PDS\_emissions tabs.

The “food\_lookup” tab is a reference to determine which food categories each FAO commodity belongs to. Within the Food System model, various data sources provide estimates that vary from food category to food category, but without consistent definition of categories. For example, in the Waste model, food is grouped according to one set of categories, while food demand growth rates are applied to an entirely different set of categories. The “food\_lookup” table allows the Food System model to account for and accommodate these various factors and outputs.

If any changes to the “food\_lookup” table are required, care must be taken to carry those updates throughout the model, with the following as guidelines:

* The ‘true’ data are housed in this ***FOOD inputs*** spreadsheet, and should be edited and updated there first.
* These data should then be copied and pasted into tabs with the same name in the ***CORE, WASTE,*** and ***EMISSIONS and YIELD*** spreadsheets.
* The more burdensome part of this update process will be that many columns located throughout the Food System model have been generated by simple VLOOKUP formulas and then converted to static data (by pasting ‘values’ only). Data can also be copied and pasted from equivalent columns after ensuring that both source and destination tables have been sorted by “sort code”. These data columns will need to be updated to ensure that model results remain accurate.
  + In the ***FOOD inputs*** spreadsheet:
    - *REF\_supply*: Demand category, Waste lookup
    - *REF\_waste*: Waste lookup
    - *REF\_demand*: Diet category, Demand category
    - *Plant-rich\_demand*: Diet category
  + In the ***CORE*** spreadsheet:
    - Plant-rich\_demand: Diet category
    - REF\_demand: Diet category
    - DIET\_waste: Waste lookup
    - WASTE\_waste: Waste lookup
    - PDS\_waste: Waste lookup
    - DIET\_supply (second table): Waste lookup
    - WASTE\_supply (second table): Waste lookup
    - PDS\_supply (second table): Waste lookup
  + In the ***EMISSIONS and YIELD*** spreadsheet:
    - *REF\_supply*: Yield category, kcal/g
    - *DIET\_supply*: Yield category, kcal/g
    - *WASTE\_supply*: Yield category, kcal/g
    - *PDS\_supply*: Yield category, kcal/g
    - *LCA\_range*: Diet category
    - *REF\_emissions*: Current (both tables)
    - *PDS\_emissions*: Current (all three tables)
  + In the ***WASTE*** spreadsheet:
    - REF\_waste: Waste lookup (both tables), Waste category (right-hand table, with data in g/cap-day)
    - DIET\_waste: Waste lookup (both tables)
    - WASTE\_waste: Waste lookup (both tables)
    - PDS\_waste: Waste lookup (both tables)

For other tabs in the ***FOOD inputs*** spreadsheet:

* The “country\_lookup” tab plays a role analogous to the “food\_lookup” table, and should be left alone unless changes to the core model infrastructure require replacing it. In this case, the “country\_lookup” table should merely be copied from the ***POPULATION inputs*** spreadsheet and pasted to replace the existing table.
* The “waste\_forecast” tab houses the critical input data used to estimate and forecast food waste, namely rates (as a percentage) of wasted food at various stages of the food life cycle (“farm to fork”), broken down by region. Since the rates provided by the key source (FAO 2011, “Global Food Losses”) do not cover all FAO commodities, a new “other” category is also generated as the average of other existing food waste rates in each given region. Source data (including these “other” estimates) are located in the tan cells. Two additional columns—one generating post-farm gate loss rates for each food waste category and region, and one generating an estimate for the percentage of food reaching consumers after pre-consumer, post-farm gate losses are accounted for—are calculated here for use in the model. To update these assumptions:
  + Like food supply, population, and demand growth rates, the “waste\_forecast” data are a key source upon which the Food System model infrastructure is built. If significant updates or changes to these data are required, it will be a substantial undertaking that ripples and must therefore be accommodated throughout the model.
  + Otherwise, values can easily and simply be changed in this table in the ***FOOD inputs*** spreadsheet, then copied and pasted into the ***CORE*** and ***WASTE*** spreadsheets, which contain tabs with the same name.
* The “demand\_forecast” tab includes data from Alexandratos et al. 2012, which provides estimates for demand growth rates for food commodity groups and by region over time. In cases where estimates of changing aggregate demand over time are given, growth rates are backed out using the SOLVER function in Excel. These instances are marked by in-cell comments on the tab, and differentiated by their green color. The resulting growth region- and commodity group–specific factors are summarized in tables starting in row 59, with results that are used to forecast changing food demand highlighted in tan. In order to update the demand\_forecast assumptions:
  + The REF forecast is generated entirely within the ***FOOD inputs*** spreadsheet—where the Diet forecast is also applied—so all changes can be made in that spreadsheet unless a new demand forecast source uses new ‘demand regions’ or ‘demand categories’, which would require changes to the “country\_lookup” tab (in the ***POPULATION inputs*** spreadsheet, which would then need to be updated in the ***FOOD inputs***, ***CORE***, and ***EMISSIONS and YIELD*** spreadsheets) and then throughout the model in lookup columns that use ‘demand region’ or ‘demand category’ labels.
  + Because the existing (Sept 2018) Drawdown framework is in part built around the Alexandratos et al. (2012) forecast as a core data source, adapting another source for use instead is likely to require more work than updating the existing values (unless the new source happens to use the same food commodity and country groupings), including updating all formulas that reference the “demand\_forecast” tab.
* The “Plant-rich\_diet” tab features data from Bajzelj et al. 2014, and describes a ‘healthy’ diet (with maximum constraints on some ‘unhealthy’ foods like “Sugar & sweeteners” and minimum constraints on ‘healthy’ ones like “Vegetables”). These values are given in terms of avg kcal/cap/day. In order to update the assumed dietary forecast:
  + Incorporating an entirely new dietary forecast would be a substantial undertaking, though it would be relatively simple to make changes within the existing Bajzelj framework if they are justified by newly reviewed literature (e.g., changing minimum or maximum values for specific foods, or further reducing red meat consumption by replacing it with other foods with similar essential nutrients).
  + To update the model’s plant-rich diet, directly edit the cells in the ***FOOD inputs*** spreadsheet’s “Plant-rich diet” tab, in the second/lower table (the first/above table adjusts the dietary demand according to overall caloric demand in the plant-rich diet, which is an input parameter for the Food System model). This is the only spreadsheet in which these values are used explicitly, so they do not need to be updated elsewhere.
  + Because the model’s structure was designed with this specific source (Bajzelj et al. 2014) in mind, updating these data would require a structural change to the model unless the updated source happens to use the same regional definitions and food categories.
* The values in the “REF\_supply”, “REF\_waste”, and “REF\_demand” tabs are a foundational input in the Food System model, expressed in kcal/cap/day. These per-capita, daily caloric supply estimates are the central dataset upon which the rest of the model is built. Updating these tabs is likely only necessary if new years of data are added and/or more substantial methodological changes undertaken, but if one needs to do so:
  + These tabs are formula-driven, so unless changes to those formulas or the model structure more broadly are required, then recalculating these spreadsheets should update them appropriately. The sheets should be recalculated in the following order (for more on why the supply and waste data need to be recalculated twice, see the Model Methodology):
    - REF\_supply
    - REF\_waste
    - REF\_demand
    - REF\_waste
    - REF\_supply
  + Once these tabs are updated, their values need to be food supply forecasts in the Food System model, sort the table by ‘sort code’ (generated by sorting first by commodity, then by country) in both tables, then copy and paste (VALUES only) from the *REF\_waste* and *REF\_demand* tabs into the tabs with the same name in the ***CORE*** spreadsheet
  + *REF\_demand* and *REF\_waste* values should also be pasted into the ***EMISSIONS and YIELD*** spreadsheet to and from the tabs with the same name, along with *REF\_supply* (which is not used in the CORE spreadsheet)
* The “Plant-rich\_demand” tab generates a per-capita, daily plant-rich diet for each country, by FAO commodity. This tab contains two tables—the table to the right (which calculates per-capita daily caloric demand by country and food commodity for the modeled plant-rich diet) does not need to be updated unless there’s a significant methodological change, and the table to the left adjusts the food quantities in the plant-rich diet to align with the input parameter assumption for average total daily caloric demand in the plant-rich diet. This tab and the “REF\_demand” tab are later combined in the ***CORE*** spreadsheet to generate the ‘Project Drawdown Scenario’ (PDS) demand, based on the annual adoption rate of the plant-rich diet. This tab only needs to be modified when changes to the diet assumptions are made in the parameters tab (unless more substantive methodological changes are adopted).
  + This tab should be updated only after updating the “REF\_demand” and “plant-rich diet” tabs. Once updated, the values should be copied into the tab of the same name in the ***CORE*** spreadsheet

*The preceding spreadsheets comprise the model ‘inputs’, which are used extensively as inputs to the Food System model, whose food demand/waste/supply and emissions scenarios are generated in the following spreadsheets. In other words, the following spreadsheets comprise an analysis of the data inputs from the preceding spreadsheets. Updating the Food System model’s data inputs will primarily require changes to the preceding spreadsheets, with some possible spillover changes to the following ones, described as comprehensively as possible above. The following spreadsheet descriptions will focus on tabs and content that is original to those spreadsheets, with minimal discussion of tabs that will merely be copied from the preceding spreadsheets during model runs.*

***CORE***

* Data in the “food\_lookup” and “country\_lookup” tables should be pasted from the ***FOOD inputs*** and ***POPULATION*** spreadsheets, respectively, if an update is required.
* Data in the “parameters”, “Plant-rich\_demand”, “REF\_demand”, “REF\_waste”, and “REF\_supply” tabs should be pasted from the ***FOOD inputs*** spreadsheet. So should data in the “Waste\_forecast” tab if an update is required.
* The “PDS\_demand” tab generates the estimated per-capita, per-day demand for each FAO commodity in each country based on the given year’s adoption of the plant-rich diet solution.
* The “PDS\_waste” tab generates the estimated per-capita, per-day waste for each FAO commodity in each country based on the “PDS\_demand” results.
* The “PDS\_supply” tab generates the estimated per-capita, per-day waste for each FAO commodity in each country as the sum of the “PDS\_demand” and “PDS\_waste” results.
* The DIET and WASTE demand/waste/supply tabs show analogous results for those two scenarios.
* The “Country\_calories” tab shows the average per-capita daily caloric intake over time by country.

***EMISSIONS and YIELD***

* Data in ”parameters”, “PDS\_supply”, “REF\_supply”, and “food\_lookup” (if an update needed) tabs should be pasted from the ***CORE*** spreadsheet.
* If an update is needed, “LCA\_range” data should be pasted from the ***LCA inputs*** spreadsheet
* If an update is needed, “pop\_REF1”, “pop\_REF2”, and “country lookup” data should be pasted from the ***POPULATION inputs*** spreadsheet
* The “REF\_emissions” (REF1 and REF2 scenarios) and “PDS\_emissions” (DIET, WASTE, and PDS scenarios) tabs generate emissions estimates by country and FAO commodity as an intermediate step in the emissions forecast calculations.
* “REF\_country\_CO2” and “PDS\_country\_CO2” generate key summary values for the Food System model, with estimated CO2e emissions by country and year.
* “REF\_commodity\_CO2” and “PDS\_commodity\_CO2” tabs generate useful summary output values for the Food System model, with estimated CO2e emissions by commodity and year.
* The “Global\_yield” tab contains more intermediate calculations, and should generally be left alone unless a change in methodology is required. This tab generates global supply estimates by yield category, in grams.
* “REF\_country\_supply” and “PDS\_country\_supply” tabs show the total mass of food supply over time, by country, for each scenario.
* “REF\_commodity\_supply” and “PDS\_commodity\_supply” tabs show the total mass of food supply over time, by commodity, for each scenario.
* The “Yield\_ADOPTION\_DATE” tab presents both REF and PDS yield outputs in millions of metric tonnes by yield category and year, for use in the yield model.
* The “Emissions\_ADOPTION\_DATE” tab presents a color-coded summary of emissions across the five scenarios and four comparative/cumulative emissions ‘saving’ calculations (Family Planning, Diet-only, Waste-only, and PDS interventions).
* The “Supply\_ADOPTION\_DATE” tab presents a color-coded summary of total food supply across the five scenarios and four comparative/cumulative emissions ‘saving’ calculations (Family Planning, Diet-only, Waste-only, and PDS interventions).

***WASTE***

* Data in the “food\_lookup” and “country\_lookup” tables should be pasted from the ***CORE*** spreadsheet if an update is required.
* Data in “Waste\_forecast” tab, in the first/left-most table, should be pasted from the ***CORE*** spreadsheet if an update is required (into the tan cells, after sorting by ‘sort code’).
  + In the ***WASTE*** spreadsheet, two additional tables are included in this tab, as intermediate steps toward generating the spreadsheet’s waste fraction values. Changes to these other tables should not be made unless a change to the methodology is desired.
  + The second table calculates the ‘percent of food supply remaining after each step in food life cycle’, an intermediate step toward generating the third table.
  + The third table calculates the ‘mass percent of total food waste stream by region and waste category’, which is a key input in the waste fraction calculation.
* Data in “REF\_waste”, and “PDS\_waste” tabs should be pasted from the ***CORE*** spreadsheet.
* Data in “pop\_REF1” and “pop\_REF2” tabs should be pasted from the ***POPULATION inputs*** spreadsheet if an update is required.
* The “REF1\_fraction”, “REF2\_fraction”, “DIET\_fraction”, “WASTE\_fraction”, and “PDS\_fraction” tabs generate estimates for total waste generated at each stage of the food life cycle. These are estimated as the product of total waste in each scenario and the mass percent of the total waste stream for each stage of the life cycle.
* The “Waste\_ADOPTION\_DATE” tab presents a color-coded summary of total food waste and municipal solid waste across the five scenarios and four comparative/cumulative emissions ‘saving’ calculations (Family Planning, Diet-only, Waste-only, and PDS interventions).

**Food System model, in summary (step-by-step process):**

Provided none of the underlying datasets or fundamental Food System model assumptions need to be updated, this is the process by which an analyst can simply run a new model scenario:

1. Start with the ***FOOD inputs*** spreadsheet
   1. REF scenarios will need to be updated only when fundamental Food System model assumptions (e.g. the input data or base demand forecast methods) change. When you need to update or re-run the REF scenarios, you should recalculate their values in the following order:
      1. REF\_supply
      2. REF\_waste
      3. REF\_demand
      4. REF\_waste
      5. REF\_supply
   2. After data in these three tabs are up-to-date—whose results are not dependent on any model input parameters—set the parameters of the scenario you want to explore in the ‘parameters’ tab (plant-rich diet and food waste adoption targets and timelines; plant-rich diet parameters; and emissions and population assumptions)
   3. Recalculate the values in the “Plant-rich\_demand” tab (which are dependent in particular on the daily plant-rich diet calorie assumption) if the “plant-rich diet” calories input has changed
      1. You will need to first drag the top row of formulae down throughout the full table before clicking “Calculate Sheet”. This is a computationally-intensive calculation
      2. After the recalculation is complete, copy and paste all tan cells below the first row and paste them in place as “Values Only” before saving
   4. Save ***FOOD inputs*** with a file extension that describes your scenario run and notes the date (e.g., “*FOOD inputs 50D\_50FW\_10-31-2018*”)
2. With both the ***FOOD inputs*** and ***CORE*** spreadsheets open, and for each of the following tabs, sort all relevant tables by “sort code” and then copy the table values (highlighted in tan) from ***FOOD inputs*** and to the corresponding table in ***CORE***:
   1. Waste\_forecast (only needs to be updated if underlying food waste inputs have changed)
   2. Parameters
   3. REF\_supply
   4. REF\_waste
   5. REF\_demand
   6. Plant-rich\_demand

NB: absent a fundamental methodology change, the “plant-rich diet” tab and the second/right-hand side table in the “plant-rich\_demand” tab should not change—as of early 2019, updates to the modeled plant-rich diet are only driven by changes to the calorie input parameter, which is accounted for in the left-hand table (titled *"Plant-rich" food demand forecast by country and FAO commodity*) in the “plant-rich\_demand” tab

1. Close the ***FOOD inputs*** spreadsheet, and recalculate the following tabs in ***CORE*** spreadsheet, in the following order (from left to right, within the spreadsheet):
   1. Waste\_forecast (if waste adoption has changed)

NB: For all subsequent tabs, you will need to first drag the top row of formulae down throughout each full table before clicking “Calculate Sheet”. These calculations should run quickly. After each recalculation is complete, copy and paste all tan cells below the first row and paste them in place as “Values Only”

* 1. DIET\_demand
  2. DIET\_waste
  3. DIET\_supply (both tables!)
  4. WASTE\_demand
  5. WASTE\_waste
  6. WASTE\_supply
  7. PDS\_demand
  8. PDS\_waste
  9. PDS\_supply (both tables!)
  10. *[Optional]: Country\_calories (will not require formula-dragging)*

1. Save ***CORE*** with a file extension that describes your scenario run and notes the date (e.g., “*CORE 50D\_50FW\_10-31-2018*”)
2. Open the ***RESULTS*** spreadsheet and \*copy\* (don’t \*move\*) the any tabs from ***CORE*** into ***RESULTS***. Rename any copied tabs with relevant info about your model run if desired. Save the ***RESULTS*** spreadsheet
3. Open the ***EMISSIONS and YIELD*** spreadsheet. With both the ***CORE*** and the ***EMISSIONS and YIELD*** spreadsheets open, copy table values from the following tabs in ***CORE*** and paste them into the corresponding tabs in ***EMISSIONS and YIELD***:
   1. parameters
   2. REF\_supply
   3. DIET\_supply (both tables!)
   4. WASTE\_supply
   5. PDS\_supply (both tables!)
4. If population values need to be updated, open the ***POPULATION inputs*** spreadsheet as well, and copy and paste population values from that spreadsheet into the corresponding tabs of the ***EMISSIONS and YIELD*** spreadsheet for both “pop\_REF1” and “pop\_REF2”. You will also need to recalculate values in the “pop\_REF1\_array” and “pop\_REF2\_array” tabs immediately below the first table in each tab, which are used in the emissions and yield calculations. Otherwise, proceed to the next step
5. If LCA values need to be updated, open the ***LCA inputs*** spreadsheet as well, and copy and paste “LCA\_range” values from that spreadsheet into the corresponding tab of the ***EMISSIONS and YIELD*** spreadsheet. Otherwise, proceed to the next step.
6. Recalculate the following tabs, in the following order. Before recalculating, however, make sure to drag the formulae down from the top row of each table (and copy then paste “values only” the second through last rows after values are updated):
   1. REF\_emissions (both tables!)—this is a computationally-intensive calculation and will take some time
   2. PDS\_emissions (all three tables!)—this is a computationally-intensive calculation and will take some time
   3. *[Optional]: REF\_commodity\_CO2*
   4. *[Optional]: PDS\_commodity\_CO2*
   5. *[Optional]: REF\_country\_supply*
   6. *[Optional]: PDS\_country\_supply*
   7. *[Optional]: REF\_commodity\_supply*
   8. *[Optional]: PDS\_commodity\_supply*
7. Recalculate the following tabs, in the following order (no formula-dragging required):
   1. REF\_country\_CO2 (all four tables!)
   2. PDS\_country\_CO2 (all \*six\* tables!)
   3. Global\_yield
   4. Yield\_outputs
   5. Yield\_ADOPTION\_DATE
   6. Supply\_ADOPTION\_DATE
   7. Emissions\_ADOPTION\_DATE
8. Save ***EMISSIONS and YIELD*** with a file extension that describes your scenario run and notes the date (e.g., “*EMISSIONS and YIELD 50D\_50FW\_10-31-2018*”)
9. Open the ***RESULTS*** spreadsheet and \*copy\* (don’t \*move\*) the final three tabs from ***EMISSIONS and YIELD*** into ***RESULTS***. Rename each of these three tabs with relevant info about your model run (e.g., “Yield\_50D\_50FW\_10-31-2018” to reference diet and food waste adoption). Do the same with any additional tabs containing information you wish to memorialize (particularly from any Optional tabs you might have calculated) before saving the ***RESULTS*** spreadsheet
10. Close ***EMISSIONS and YIELD*** and open the ***WASTE*** spreadsheet
11. With both the ***CORE*** and the ***WASTE*** spreadsheets open, copy table values from the following tabs in ***CORE*** and paste them into the corresponding tabs in ***WASTE***:
    1. Waste\_forecast (only needs to be updated if underlying food waste inputs have changed)
    2. REF\_waste
    3. DIET\_waste
    4. WASTE\_waste
    5. PDS\_waste
12. If population values need to be updated, open the ***POPULATION inputs*** spreadsheet as well, and copy and paste population values from that spreadsheet into the corresponding tabs of the ***WASTE*** spreadsheet for both “pop\_REF1” and “pop\_REF2”. Otherwise, proceed to the next step.
13. Recalculate the values in both the following tabs, after dragging formulae from the first row all the way to the bottom of the table (copy and paste as “values only” the second through last rows after recalculating):
    1. REF1\_fraction
    2. REF2\_fraction
    3. DIET\_fraction
    4. WASTE\_fraction
    5. PDS\_fraction
14. Update the MSW parameters in the “Waste\_ADOPTION\_DATE” tab if necessary. Otherwise move on to next step
15. Recalculate values in the “Waste\_ADOPTION\_DATE” tab. This is computationally intensive and will take some time
16. Save ***WASTE*** with a file extension that describes your scenario run and notes the date (e.g., “*WASTE 50D\_50FW\_10-31-2018*”)
17. Make a \*copy\* of (do not \*move\*) the ***WASTE*** spreadsheet’s “Waste\_ADOPTION\_DATE” tab into the ***RESULTS*** spreadsheet and rename it using the same convention established for the ***EMISSIONS and YIELD*** results, which should already be in the ***RESULTS*** spreadsheet. Do the same with any additional tabs that you wish to memorialize before saving the ***RESULTS*** spreadsheet
18. Close the ***WASTE*** and ***RESULTS*** spreadsheets, take a deep breath, and give yourself a well-deserved pat on the back.