

How to use the DELTA model

The following document describes the standard operating procedure for use of the DELTA Model 1.3 Web version. The DELTA Model is a global food system mass balance that uses information about current production of major food items to predict the nutrition available to the average global citizen both now and in the future.

The model allows you to adjust the level of different food groups to see the impact of these changes on human nutrition. You can compare different possible scenarios side by side to understand the cause and effect relationship between the global food system and human nutrition.

More information about the model and its role with the Sustainable Nutrition Initiative can be found on the [website](#).

When using the model, you should be aware that:

- The DELTA model is not designed to find 'the right answer' to providing a sustainable and nutritious global food system. Rather, it is designed to promote exploration and discussion on the role of different aspects of the food system in providing adequate nutrition to the global population.
- The environmental footprint of the global food system is great and is not currently included in the DELTA model. Although it is easy to model sufficient nutrition for an increasing global population by setting food production at a much higher level than the current baseline, this may not be environmentally sustainable or even possible. In exploring the model, you should aim to achieve a food system that meets the recommended daily intake (RDI) requirements of the global population, without excessive per capita energy intake, all while considering whether the modelled food system is both possible and practical

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Initial setup of the model

Clicking on Explore the Future on the [website](#) navigation bar takes you to the DELTA model user interface. You are greeted by the Welcome page, which gives an overview of the global challenge of nutrition. You can reach the user interface by clicking on 'Model' on the navigation bar, or 'Start Exploring the Food System' on the page.

The user interface consists of two main panels: the Scenario Editor on the left hand side, and the model output on the right. The Scenario Editor should be addressed first.

A useful feature of the DELTA model is the ability to compare two food system scenarios side by side. As such, the Scenario Editor features two columns of input boxes labelled Scenario 1 and Scenario 2. Below these headings are several entry fields you can use to edit the values of food system variables for each scenario.

The default scenarios

The first dropdown box below each scenario heading contains the default scenarios. These are present-day and future food system scenarios built into the DELTA model to give you reference scenarios with which to compare alternatives, as well as starting point scenarios for future food systems. The default scenarios on opening the model are the 2018 Baseline scenario and the 2030 Baseline scenario. See Box 1 for a description of all the pre-set scenario options.

The ability to view two scenarios side by side allows the user to easily see the impact of changes to the food system.

For example, both Scenario 1 and Scenario 2 could be set to the same scenario initially, allowing the user to explore how a decrease in one variable alters the overall nutritional outcomes of the food system.

Box 1 Description of the pre-set scenario options in the Scenario Editor

2018 Baseline	Reflective of the current global food system
2030 Baseline	Identical to 2018 Baseline, but with the forecast global population for 2030 of 8.6 billion
2030 Scale-up Current	Identical to 2030 Baseline, but with production in all food groups increased by 12% to match the population increase
2030 Scale-up Fish Constrained	Identical to 2030 Scale-up Current, but with the Fish/Seafood food group held at the 2018 Baseline level
2030 Pescatarian (w Dairy)	All Meat and Eggs production are set to 0; Fish/Seafood is constant; Dairy and all Plant foods are increased from the 2030 Baseline level
2030 Vegetarian	All Meat and Fish/Seafood production are set to 0; Eggs is held constant; Dairy and all Plant foods are increased from the 2030 Baseline level
2030 Vegan	All Animal foods are set to 0, while all Plant foods are increased from 2030 Baseline level

Making changes to the global food system

Year

Moving through the Scenario Editor, you can next choose the scenario year. The DELTA model then takes the population and demographics (either recorded or forecast) for that year as input. The DELTA model assumes equal distribution of food to all; therefore, the total food supply will be divided by the global population to give per capita nutritional values.

Reference Diet

The Reference Diet setting allows you to select from Base, Vegan or Vegetarian options. While the DELTA model handles the bioavailability of amino acids in individual foods (see [Include bioavailability](#), later in this section), the bioavailability of minerals such as iron and zinc from plant foods is not yet fully understood for the majority of food items. As such, the DELTA model sets a higher target intake for these minerals under the Vegan and Vegetarian options here, to ensure that the lower bioavailability of these minerals from plant foods is accounted for. If considering an entirely or largely plant-based scenario, the Vegan or Vegetarian setting should be chosen as such.

Primary Production

The Primary production section allows you to set the global production of six animal and nine plant food groups. The Total Animal and Total Plant values display the overall production of each food group (in billions of tonnes).

Secondary Modifiers

The final section of the Scenario Editor allows you to change the waste allocation of the model. By default, both the Supply chain waste and the In-home waste are set to 1x, the baseline level of waste for 2018. The sliders can be moved to represent a greater or lesser proportion of waste, with the value below the slider indicating the total food wasted (in millions of tonnes).

The *Include bioavailability* tick boxes allow you to toggle the inclusion of protein and amino acid bioavailability in the model. It is known that the ability of the digestive system to obtain amino acids from foods is dependent on the food being digested. The DELTA model accounts for this by scaling amino acid absorption by the bioavailability of these molecules in each food.

Scale of 'Other Uses'

Many food commodities are removed from the food supply chain before reaching the consumer for use in other products or services (e.g. sugar cane use in biofuel production). The DELTA Model allows you to decide whether these other uses should be held constant at the 2018 Baseline level, scaled by the population size (i.e. a greater population results in greater alternative use of the product), or scaled by the availability of the individual commodities being used (i.e. more of the food being produced results in more being taken for other uses).

Interpreting the model outputs

As you update variables in the Scenario Editor, the DELTA Model will simultaneously update the outputs on the right-hand side. These outputs are displayed in several tabs, each of which pertains to a certain aspect of the food system and global nutrition.

Main

The Main tab gives you an overview of the total mass of edible product produced under each scenario, as well as a breakdown of how much of this total goes towards feed, how much is wasted and how much is inedible once it reaches the consumer (e.g. vegetable skins).

Importantly, the Main tab shows you the nutrient gaps; that is, where the food production in each scenario falls short for meeting per capita RDI requirements. In designing a sustainable nutrition food system, all nutrient gaps must be closed to ensure adequate nutrition for the global population. Therefore, a scenario with no nutrient gaps on the summary page is capable of meeting the nutritional requirements of the global population set in the Scenario Editor under conditions of equal food distribution.

If you find that there are nutrient gaps in your model system, the Nutrient Density tool can be useful in selecting appropriate food groups increases to close these gaps (see [Helpful: Nutrient Density](#), in a later section).

Finally, the Main tab displays bar charts comparing the nutritional performance of the two scenarios for six key nutritional factors: energy, protein, fat, carbohydrates, fibre and lysine. The target intake for each of these factors is indicated by the black horizontal bar. The grey connected bars indicate upper and lower safe intake boundaries. The charts are colour coded to indicate the contribution of different food groups to the overall total.

Nutrition: Nutrient Supply

The Nutrient Supply tab provides further charts of the kind seen on the Summary tab, but for all nutrients considered by the model: macronutrients, micronutrients and minerals. Each individual chart compares the performance of the two dietary scenarios in providing sufficient bioavailable amounts of each nutrient, colour coded to indicate the relative contribution of five animal and plant food groups.

This tab enables you to visualise the size of any nutrient gaps, as well as giving a clear indication of any nutritional factors that are supplied in excess.

You should use the Nutrient Supply tab to compare nutrient gaps between scenarios and ensure that there is not too great an allocation of energy or certain macronutrients (Fat and Carbohydrates).

Nutrition: Nutrient Breakdown

In the Nutrient Breakdown tab, you can see how different individual food items contribute to the overall supply of each nutrient.

First, select a nutrient from the dropdown list at the top of the page. As an example, we will use the default settings, displaying the breakdown for energy from Scenario 2 (2030 Baseline scenario). The slider on the right-hand side allows you to choose how many food items to view in the chart – the default of ten is a good place to start.

Initially, the chart shows the top ten foods items that contribute to overall energy supply in the selected scenario. The bars of the chart are colour coded by the broader food group that the food items belong to.

The tick box above the chart allows you to switch between viewing food items and broader food groups. Both can be useful to illustrate where a selected nutrient is derived from in a scenario.

Use the Group Breakdown tab for a closer look at how different foods contribute to the overall supply of an individual nutrient.

Nutrition: Nutrient Contribution

The Nutrient Contribution tab gives each food item (or group) in the DELTA Model a score, based on its overall contribution to global nutrition.

Similarly to the Nutrient Breakdown tab, you can select a scenario, the number of items to view in the chart, and whether to view scores for individual food items or for the broader food groups. The DELTA Model calculates a score for each food item by taking the proportion of each nutrient supplied by the food item, and then summing these for all nutrients. Energy and carbohydrates are excluded from the calculation, as a high contribution to these values is not necessarily beneficial to the global population.

Use the Nutrient Contribution tab to isolate which food items make the greatest contribution to global nutrition in a scenario. Removal of a food item at the top of the Nutrient Contribution list from the system would result in a greater change to overall nutrition than removal of a food item low on the list.

In the default 2018 Baseline scenario, the top Nutrient Contribution score is held by Rice (Milled Equivalent). This is due to a combination of the nutritional content of rice, which includes protein and a number of vitamins and minerals, and the high production quantity of rice in this scenario. When you change the tick box at the top of the page to show food groups instead of items, Cereals – Excluding Beer holds the top Nutrient Contribution score. As well as being a source of many nutrients, cereals constitute a large proportion of the 2018 Baseline diet, increasing their score compared to similarly nutrient rich foods that are eaten in lesser quantities.

Waste: Nutrient Waste

The Nutrient Waste tab displays the amount of each nutrient that is present in the food system but is not consumed as food, due to either supply chain or in-home losses of food items. The nutrient waste quantities will change when the waste sliders in the Scenario Editor are changed, but also when the production quantities of food groups are changed. The charts are laid out in the same way as the Nutrient Supply tab, with black horizontal bars to indicate the global target intake value.

The Nutrient Waste tab allows you to see which nutrients are wasted to the greatest extent, as well as the source of this waste. In the 2018 Baseline Scenario, it can be seen from the colour coding that the majority of nutrients wasted are from plant foods.

Waste: Waste Breakdown

Similarly to the Nutrient Breakdown tab, the Waste Breakdown tab allows you to view the amount of each nutrient wasted on a per capita per day basis in the selected scenario.

The percentage of each food item or group wasted is also shown. Moving the slider to a high number shows that fruits and vegetables have high waste proportions, whereas vegetable oils have low waste proportions.

Supply: Balance Sheet

The Balance Sheet tab shows the allocation of each of the 15 input food groups at various stages of the supply chain.

Use the slider to select a supply chain stage to view:

- Stage 1 includes primary commodities and their co-products (e.g. Sugar Cane).
- Stage 2 includes the immediate processing outputs for Stage 1 (e.g. Sugar).
- Stage 3 includes the products of further processing (e.g. Alcohol).

Upon selecting a stage, the charts below the slider will update to show how each food group is split into different branches of the food supply chain for the selected stage. The results are colour coded into seven elements:

Feed	Used as animal feed (essential if any animal source foods are included in the scenario)
Food	Consumed by humans. This excludes all food waste
In-home Waste	Edible food that reaches the consumer but is not consumed (e.g. not used by a best before date and discarded, or leftover food thrown away after a meal)
Losses	Supply chain waste
Other uses	Non-food related uses (e.g. sugar cane use in biofuel production, animal fats used for soaps)
Processing	Food that is processed to another food product captured within the food balance sheets (e.g. grapes to wine)
Seed	Portion of a food item that is withheld to allow for future food production

You can use the Supply Balance tab to learn the uses of the input food groups at different stages of the supply chain.

Supply: Supply Chain

The Supply Chain tab gives a slightly different view of the allocation of the 15 food groups to the Balance Sheet tab. On selecting a food group, you can then see sequentially how the total mass of that food group is directed.

The sugar food group provides a good example. Using this group, you can see that a high proportion of Stage 1 products are directed to further Processing, with only a small proportion allocated to Food. As shown in the tables below the charts, this is because Stage 1 products are primarily sugar cane and sugar beet, which require processing before most food uses.

At Stage 2, the Food proportion of the total quantity is greater, as the sugar crops have been refined to edible sugar. However, it is also clear that this has resulted in a significant reduction in the overall mass of product – the processing of sugar cane and beet to refined sugar has a low yield, with some water mass removed during the process.

Supply: Daily Supply

The Daily Supply tab takes the 15 input food group production quantities and expresses them graphically by their contribution to per capita food mass consumed per day.

You can select which scenario to view, and the model returns a chart showing the mass of each food group that will be consumed by the average global citizen each day under that scenario. The chart is further split into solid and liquid forms of the food group.

Mass of food consumed is an important factor in human nutrition. It can be helpful to see how a future scenario compares to the 2018 Baseline in terms of total mass consumed (around 1.5 kg) and the dominant food groups making up the diet. These variables contribute to how practical and acceptable any future scenario might be to the individual.

System Change

The final Model tab gives a visual representation of how different the two defined scenarios are, both in production and food supply.

The Production Ratio Change calculates the relative change from Scenario 1 to Scenario 2 in terms of the user input food group production values. When comparing the 2018 and 2030 Baseline Scenarios, the only differences are caused by the demands of a slightly larger population, with a higher average age.

Similarly, the Food Ratio Change chart calculates the relative change in food supply, after waste, processing and other uses have been accounted for. In the default comparison, there are a number of changes of varied magnitudes. These are predominantly due to the Scale of Other Uses in the Scenario Editor being set to Population. This means that an increased population size put increased demands on the use of food commodities for other uses, such as fuel. Setting Scale of Other Uses to either Availability or Constant results in minimal change differences between the two baseline scenarios.

For a closer view, the charts can be toggled to display the system change for individual food items, rather than food groups.

The System Change tab informs you how different two scenarios are overall. This can be important in assessing how feasible a newly defined scenario is in terms of the global change that would be necessary to implement it.

Designing future food scenarios

There are many factors to consider when modelling a sustainable nutrition scenario for an increasing global population. You should ask first whether your scenario is possible: are the nutritional needs of the global population met, without requiring food production that is beyond the capacity of global sustainability boundaries?

Next, you should ask whether your scenario is practical: in reality, is it possible to achieve the level of waste set in the model, or the decreased level of a certain food group that may be a staple for some cultures?

Finally, you should ask whether your scenario is optimal: is your scenario the best target that the global food system should aim for, or are there other scenarios that can achieve sustainable nutrition with less system change, or a lesser environmental footprint?

The DELTA Model has some resources to assist you in building scenarios. The Helpful tab contains information on global demographics, the nutrient densities of different foods, and descriptions of the food groups and items used by the model to enable scenario fine-tuning.

Helpful: Demographics

The Demographics tab shows the age distribution of the global population. You can select which years to view, as well as the selecting either the global population or that of a large region. This information is important, as the DELTA Model intake targets values are weighted by the target values for each subset of the global population.

Helpful: Nutrient Density

The Nutrient Density tab allows you to isolate which food items in the DELTA Model are rich in a specific nutrient.

You are required to set a Targeted Nutrient and a Dietary Constraint to view. The model then calculates the ratio of the Targeted Nutrient per unit of the Dietary Constraint for all food items and returns a chart displaying the food items with the highest ratios on the left-hand side. You can set the number of food items to view using the slider.

For example, you may wish to increase phosphorous in your scenario without adding to the total fat. Setting the Targeted Nutrient to phosphorous and the Dietary Constraint to fat, you would see that the foods with the highest phosphorous to fat ratio are root vegetables. You could then adjust your scenario accordingly.

The chart on the right-hand side of the Nutrient Density tab displays the quantity of each food item present in the 2018 Baseline diet. In our example, this shows that the phosphorous to fat ratio of sweet potatoes is greater than that of potatoes, but that the latter makes a greater contribution by mass to the 2018 Baseline diet. This information is useful in deciding whether it would be more practical to achieve higher dietary phosphorous by increasing sweet potato consumption, versus a proportional increase in potato consumption, a food item that is more widely produced and consumed already.

Another useful function of the Nutrient Density tab is to display bioavailability. If you set both the Targeted Nutrient and Dietary Constraint to the same variable, the model returns the bioavailability coefficient for that variable for each food item. The left-hand chart shows how readily absorbed the Targeted Nutrient is from each food item. A value of 1 indicates that all the selected nutrient is absorbed from that food, while a value lower than 1 indicates that only a proportion of the nutrient is absorbed. For both carbohydrates and fats, the DELTA Model assumes complete bioavailability, so all food items have a value of 1. However, for protein, the model gives a bioavailability value of for all food items, based on bioavailability data. As can be seen in this chart, animal foods generally have high protein bioavailability, whereas plant foods have more variable bioavailability values.

Helpful: Model Structure: Composition Model

The Composition Model page allows you to see the food groups, items and types considered by the model. It also includes food composition data and key references used in the construction of the model.

The top section of the tab deals with the food production groups, the largest classification of the model. You can select a group to view, and the section displays the food commodities that make up that food group, as well as their relative mass contribution to the overall food group total. For example, you can see under Cereals that Maize, Rice and Wheat make up the majority of this food groups, with lesser contributions from other cereal types. Secondary and tertiary commodities (those produced from processing of primary commodities) are also displayed.

The second section of the model gives a breakdown of commodities at the next level of specificity. A commodity from the upper level (e.g. Rice), can be selected from the dropdown list, and the constituent food types within this commodity (e.g. White Rice and Brown Rice) are shown. The section also shows the fraction of the total commodity made up by each food type (e.g. 80% White Rice and 20% Brown Rice); the yield of the food type from prior processing (e.g. 100% for Rice, due to minimal processing losses); and the inedible portion of the food type (e.g. 0% for Rice, as the whole food can be eaten). Finally, the description column gives some justification or reference for the preceding values.

The third section of the Composition Model tab shows the highest level of specificity of the DELTA Model. A food type can be selected from the dropdown list, and any further breakdown of that food type is shown, along with the relative contribution to the food type. For example, under White Rice, you can see that short-, medium- and long-grain rice are considered in various proportions. This level of resolution allows the USDA food composition database to be used to derive the nutrient content of each food.

The final section of the Composition Model page allows you to view the effective nutrient content of a food commodity, derived from the weighted average compositions of its constituent food types. Macronutrient, mineral, vitamin and amino acid content can be viewed, along with the bioavailability coefficient (where available) of the nutrient from each commodity.

Helpful: Model Structure: Food Item Linkages

The Food Item Linkages page displays two data tables. The first details the co-products of primary production that are considered by the model. For example, the DELTA Model

includes 0.14 tonnes of edible bovine offals for every tonne of bovine meat entered as primary production.

The second table details the links between primary food commodities and their processed products. For example, 21% of the 'Apples and products' allocated to processing are used for Cider Brewing. Of this amount, there is a 50% yield of 'Beverages, Fermented'. The other processing paths for the remainder of the processed 'Apples and products' are also shown. Similarly, 100% of the processing allocation of 'Barley and products' is used for Beer Brewing, with a 484% yield of 'Beer'. This high mass yield is due to the addition of water

Helpful: Nutrient Distribution: Nutrient Movement

The Nutrient Movement page allows you to see how nutrients (rather than foods) are traded between countries. Select a country and nutrient of interest using the dropdown boxes on the left-hand side of the page. Three charts for this nutrient are shown on the right-hand side.

The first chart shows the production, trade and domestic availability of that nutrient, on a per capita per day basis. For example, when averaged out to per capita per day units, Algeria produces around 1200 kcal of food energy. This is largely from plant sources, as shown by the colour coding. Algeria imports around 2100 kcal and exports a small amount. The 'Eaten' bar on the chart gives the result of the equation: Produced + Imported – Exported, thus the availability of food energy domestically. Identically to the other DELTA Model charts, the horizontal black line on the 'Eaten' bar shows the target daily per capita intake for the average Algerian, and the range bars show the safe upper and lower limits. The dashed line shows the global average availability of food energy.

The second and third charts on this page show the same information as the first, but for firstly the sub-region, and then the region. This can show the variation between an individual country and its neighbours. For example, energy availability in Algeria is above the global average (dashed line), whereas the average availability for Africa is below the global average.

Below the charts is the population of the country, sub-region or region to which the chart pertains. The food production and trade of several countries are not accounted for in the FAO food balance sheets, and thus not accounted for in the DELTA Model. These countries, and their populations, are noted in the tables below the charts.

Finally, there is a tick box on the left-hand side labelled 'Show all trade nutrient flows'. The default setting shows all flows, both in and out, for each food group. If unchecked, the charts show net flows instead.

Helpful: Nutrient Distribution: Nutrient Variation

The Nutrient Variation page shows a single chart. This chart shows the availability of all nutrients considered by the DELTA Model as a proportion of the target intake for that nutrient. The coloured bars show the global average, while the range bars show the 10th and 90th percentiles, i.e. the range of nutrient availability in different countries. The bars are colour coded by the position of the global average availability compared to requirement: red for below, amber for just above, and green for substantially above.

A key takeaway from this chart is that even for nutrients coloured green, such as Vitamin C, the variation in availability of this nutrient means that availability in many countries is below the requirement.

Saving your data

It is possible to spend a long time designing and investigating the potential of different scenarios. In order to keep your work for future sessions, or to export the obtained data for external use, the DELTA Model has some data management tools.

Files: Scenario Manager

The Scenario File Manager lets you add to the existing preset scenarios. Simply define a scenario in the Scenario Editor under the Model tab, and then add it to the Presets under the Add My Current Scenarios to Presets heading. You will then see your scenario name under the dropdown list in the Scenario Editor.

At the end of your session, you should use the Scenario File Manager to Export Preset List. This downloads the current preset list (including any presets you have added) as a .csv file. Then, the next time you open the DELTA Model, you can use the Import Present List function to upload this .csv file, and continue working with your preset scenarios.

Files: Export Results

Under the Export Results tab, you can download the current Scenario Parameters from the Scenario Editor; the Calculated Food Balance (after waste, processing and other uses); and the Calculated Nutrient Supply (after bioavailability considerations) as .csv files for external use.