

Revising Supply Utilization Accounts for a Single Commodity Tree: A Targeted Tool for Improving Supply Utilization Accounts and Food Balance Sheets¹

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Abstract

The compilation of Supply Utilization Accounts (SUAs) and Food Balance Sheets (FBSs) depends on a comprehensive balancing algorithm that ensures consistency across more than 400 food items and 190 countries. However, even minor revisions to a single commodity can trigger cascading recalculations across interconnected commodity trees and time series, making updates resource-intensive and time-consuming. This limits efficiency and delays the release of key food security indicators.

Addressing this challenge is critical to maintaining timely, reliable statistics that inform indicators such as dietary energy supply, import dependency, and self-sufficiency ratios. To improve efficiency, FAO has developed the Single-tree algorithm, which allows isolating a specific commodity tree across multiple years without recalculating the entire system.

The results show significant gains in speed, analytical control, and transparency when revisions are limited in scope. Rather than replacing the standard method, the Single-tree algorithm complements it, providing a flexible and more responsive framework for managing time-series revisions while preserving methodological rigor.

1. Introduction

The compilation of the Supply Utilization Accounts (SUAs) and Food Balance Sheets (FBSs) is one of the key activities of the Food and Agriculture Organization (FAO) to provide timely, coherent and internationally comparable statistics on food supply and utilization, covering over 400 food items in 190 countries. The methodology for compiling SUAs involves a balancing identity, in which supply data—comprising production, imports, and changes in stock—is matched with utilization data, including exports, food consumption, feed, seed, food processing, industrial use, losses, and residuals, for each calendar year and agricultural commodity produced or traded in a country. The FBS construction follows the SUA compilation where each account is systematically standardized and organized at primary commodity equivalent (e.g., the account of *wheat and meslin flour* is converted into the *wheat and product* one). FBSs and SUAs provide a framework for monitoring of agrifood systems and food supply in a country and are crucial for evidence-based policy making and planning. They provide a comprehensive picture of food availability in a country in terms of quantity of food available per capita as well as in terms of dietary energy and nutrient availability. Food Balance Sheets have been used for estimation of

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SDG indicator 2.1.1. They have been used for analyzing adequacy, diversity and resilience of food supply at the national level through the use various indicators such as Dietary Energy Supply (DES), Import Dependency Ratios (IDR), Food Self-Sufficiency Ratios (SSR), Dietary Sourcing Flexibility Index (DSFI). The Section 2 of this paper briefly describes the current FAO SUA/FBS compilation methodology and points out some of its limitations. The Section 3 introduces the single-tree algorithm, a targeted method that was recently designed to enhance the quality of the SUAs and deal with some of these limitations. The Section 4 presents a practical example of the Single-tree algorithm application. The Conclusions discusses the results of applying the single-tree algorithm and highlights the cost–benefit trade-off of adopting it instead of the traditional balancing algorithm.

2. Section 2. Methodology and Concepts

The SUAs and FBSs are based on the idea that the total supply of a given agricultural product in a particular country must equal the total utilization of that product in a given year. In SUAs, this principle is expressed as an identity (Equation 1) that sets total supply equal to total utilization. When this occurs, the equation is said to be *balanced*.

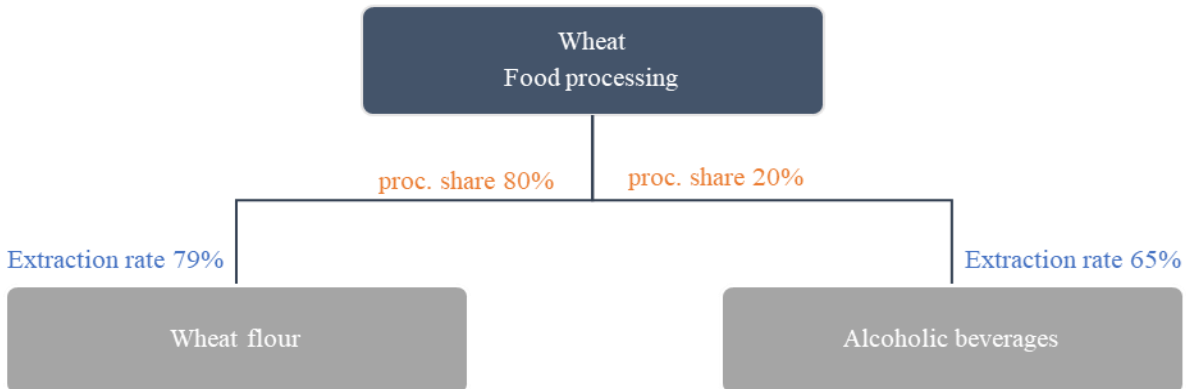
Equation 1. Basic SUA identity

Total supply = total utilization (identity at the SUA level)

$$\textit{production} + \textit{imports} - \Delta\textit{stocks} = \textit{exports} + \textit{food} + \textit{food processing} + \textit{feed} + \textit{seed} + \textit{tourist consumption} + \textit{industrial use} + \textit{loss} + \textit{residuals}$$

The process that leads to this identity being respected is called the *balancing mechanism*. The balancing is carried out for each commodity using balancing algorithms designed to perform a semi-automatic availability allocation based on several statistical models that use historical data series as well as different parameters that are expected to drive utilization of portions of supply for different purposes. The compilation of SUAs and the balancing mechanism uses the concept of commodity trees. A commodity tree is a “symbolic representation of the flow from a primary commodity to various processed products derived from it, together with the conversion factors from one commodity to another” (FAO, 2001). Figure 1 shows a simplified commodity tree schema and illustrates the example of processing of a parent item, which may be a primary or secondary commodity, into derived or child commodities.

Figure 1. Wheat tree



In the SUAs, the utilization element of *food processing* (see Equation 1), which captures the quantity of a certain item allocated to the processing of its derived products, connects the SUA of one commodity with the SUAs of its parent and derived products. The ratio between the quantity used for *food processing* variable of a parent item and the *production* of the derived commodity is dependent on two key concepts: the *extraction rates* and the *processing shares*. The extraction rate (i.e., the blue factors in Figure 1) represents the quantity of output obtained when the parent item is processed to produce a particular child. For instance, an extraction rate of 79 per cent means that 790 kg of wheat flour are produced when 1 tonne of wheat grain is milled. These extraction rates are dependent on the technology used for processing and can vary across countries and over time. There are two types of processing shares used in SUA methodology.

The *up-processing shares* (i.e., the orange coefficients in Figure 1) represent the division of the total quantity of a parent item that is used for production of different derived items. In the commodity tree presented in Figure 1, of the total quantity of wheat that is processed, 80 per cent is used for production of flour and its co-products, while the rest is used for production of alcoholic beverages. Extraction rates are specified for different co-products that are produced in a specific process. The *down-processing shares* define how much of a child is produced from different parent items that might be used for production of the same child (e.g., the share of alcoholic beverages that are produced from wheat and other parent items like barley).

Figure 1 is a very simplified representation of the structure of a commodity tree. In reality, commodity trees can widely expand horizontally (i.e., one parent item having several processes and derived items) and vertically (i.e., multiple stages of processing from primary commodity to final child commodities). The form and depth of each country's commodity tree depend on many factors, such as the level of development of food processing industry, technologies in use, the

socio-economic and cultural practices related to the pattern of food consumption, the import and export of processed commodities, and the availability of official and unofficial statistics. The complexity in compiling SUAs lies in balancing the supply-utilization equation for all the item accounts available in the country, respecting the different production processes across all the commodity trees to obtain an accurate estimate of the quantities allocated among all utilization variables, not least the utilization of food (i.e., human consumption) from which, by applying population data and nutrient statistics, the indicators mentioned in the introductory chapter of this paper can be deduced.

SUA balancing algorithm limitations

Compiling the SUAs dataset for each country consists of studying the country's agrifood system and ensuring consistency among all the elements of the equation for each item individually as well as across the commodity trees. The estimation models used for filling the gaps in availability of data and the balancing algorithms have been designed to respect the constraints imposed by presence of official data on various elements for different items and the technical conversion factors including extraction rates and processing shares. The traditional algorithm used for balancing incorporates all the existing commodity tree relationships and data constraints enabling any inconsistencies to be analyzed and resolved. Once this analysis is complete, it can be inferred that the country final SUA is compiled, with most of the account imbalances resolved, and the parameters such as the processing shares falling within the variable boundaries and constraints defined by the specific national conditions and data. The balancing algorithm works on the entire data framework, capturing all the ramifications of the various commodity trees, and requires a long processing time both for the data domain analysis and the resolution of the imbalances before they are finalized. Such structure inherently suggests that any changes in the scenario, such as the availability of new official information, revision in produced/traded volumes, extraction rates, and historical data series, can impact not only one single commodity tree of the SUA but also other trees horizontally and vertically. This can require the entire SUA to be reanalyzed to return to a new point of equilibrium in the system.

The SUA compilation is not just constrained by the structure of the commodity tree; the Supply Utilization Accounts for a year are connected to the Supply Utilization Accounts of previous years in two respects. First, closing stocks of all commodities in the previous year become opening stocks in the current year. Thus, the possibility of utilizing leftover stocks from the previous years, for example, to deal with lower production or imports, is constrained by whether the country had leftover stocks from previous years. Secondly, the data for earlier years are used in the estimation models and therefore influence the estimates being obtained for the current year.

This means that Supply Utilization Accounts cannot be revised for a particular year in the past without revising SUAs for all the following years.

The single tree algorithm addresses the inflexibility of the traditional balance algorithm, which works on all products and trees within a country's SUA framework simultaneously and comprehensively. It allows the SUA analyst to revise the Supply Utilization Accounts of a targeted commodity tree for multiple years

3. Section 3: The methodological approach

The single-tree algorithm is used to update a specific item in the dataset supply utilization accounts for a given country and time frame, particularly when new official information is received or corrections are required. This process can include adjustments to any variable in the SUA equation, both on the supply side and the utilizations side.

If any of these variables are changed, the other components of the SUA for that item must also be updated to keep the SUA equation balanced. For instance, an increase in official production of a specific crop requires the adjustment of one or more variables on the utilization side, such as food or feed. Additionally, altering the supply of a particular item can affect the supply of related derivative products, and the reverse can happen as well.

The single-tree algorithm allows quick, targeted adjustments to the main item and its direct derivatives without impacting the entire commodity tree or causing chain effects, ensuring predictable results.

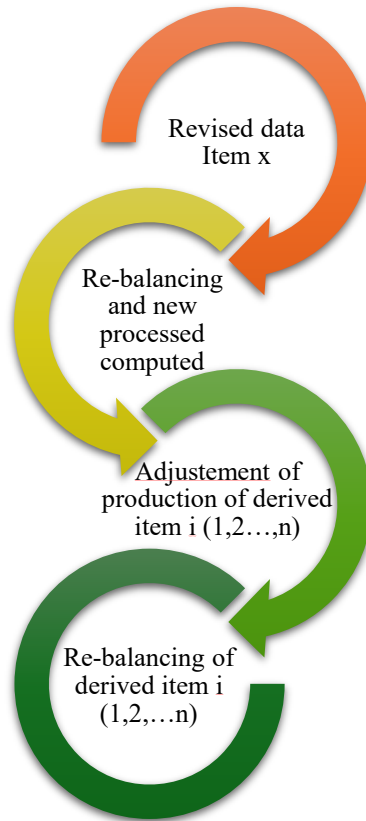
The general approach

The starting point for the application of the single-tree methodology is the revision of one or more variables (such as production, imports, or food) for a specific item across selected years. This initial step is essential to ensure that the subsequent re-balancing process is based on the most current and accurate data.

Once the relevant variables have been updated, the analyst can execute the single-tree algorithm. This algorithm will re-balance the supply utilization account (SUA) for the targeted item and, if necessary, recalculate processed and first-level derived products. The process offers flexibility, allowing the analyst to choose whether to re-balance only the main item without modifying the food processing variable, or to extend the re-balancing to include the first-level derivatives.

The overarching approach of the single-tree methodology is top-down. As depicted in Figure 2, the process begins with data updates for a given item (e.g. Item x). The SUA for Item x is then re-balanced and, if necessary, a new food processing value is calculated. Following this, the production figures for first-level derivative products are adjusted in accordance with the updated food processing values, and the SUAs for these derived items are also re-balanced. This structure ensures that changes are systematically and predictably propagated through the relevant components of the commodity tree.

Figure 2. General workflow



Protected and Unprotected Derived Products

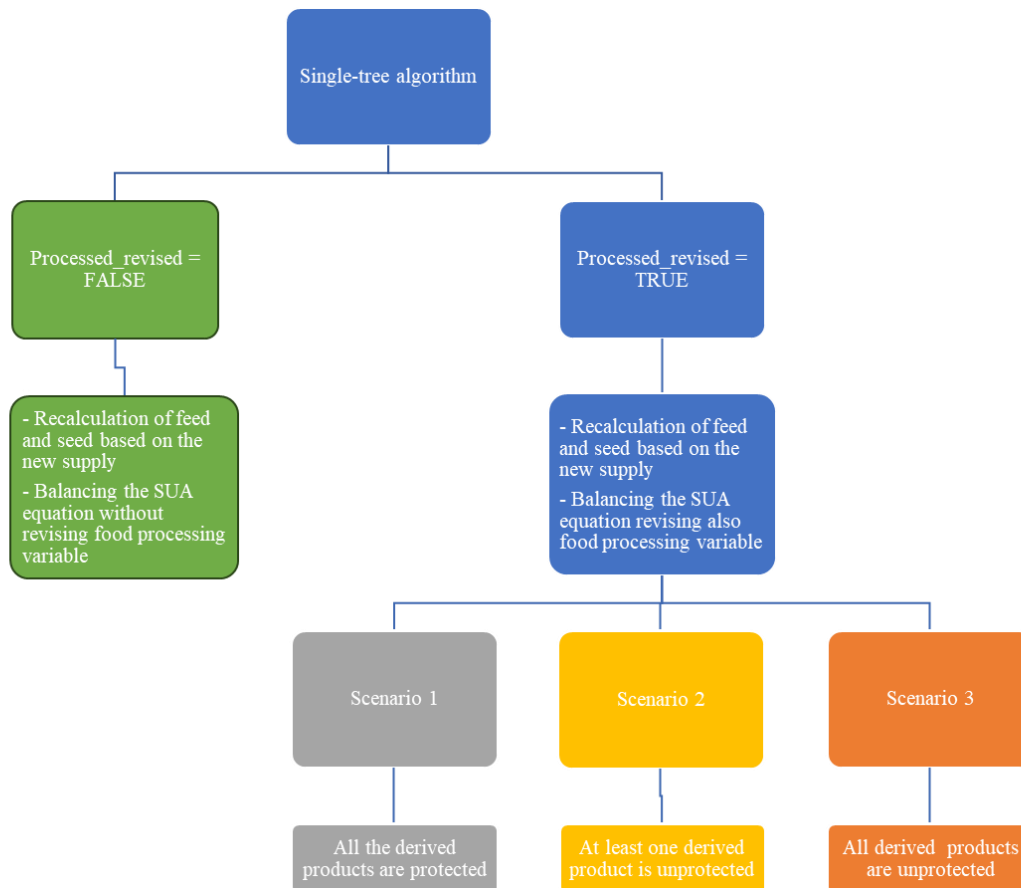
The SUA/FBS methodology uses a system of flags – which record the source of information (observation flags), and the method of obtaining/estimating the value (method flags). A combination of observation and methods flags is used to categories values that are considered reliable and accurate, and are treated as “protected” by estimation and balancing algorithms. For example, all official and some specific non-official sources of data are treated as reliable and are protected.

Following this convention, the single-tree algorithm is designed to modify only those values that are not protected by the observation and methods flag combination. However, in addition, the single-tree algorithm treats those derived products as protected which have more than one parent item. This additional constraint is important to isolate the impact of the revision to a single commodity tree, and not allow the adjustments to spread to rest of the Supply Utilization Accounts. Therefore, when the single-tree algorithm is applied, modifications are limited to unprotected derived products to ensure that the integrity of official or semi-official data and the stability of other commodity trees are maintained. This selective approach helps to avoid unwanted ripple effects across the entire Supply Utilisation Account while allowing for targeted adjustments.

Structure of the Single-tree Algorithm

The single-tree compilation routine is designed for flexible application in various scenarios. The analyst is able to select both the specific item and the range of years for which the compilation should be performed. Additionally, the process allows for customization regarding the level of update: it can be executed solely at the primary level by setting the `processed_revised` parameter to `FALSE` or extended to include first-level processed items by setting `processed_revised` to `TRUE`.

Figure 3. Structure of single-tree algorithm



Case: `processed_revised` = FALSE

When the `processed_revised` parameter is set to `FALSE`, the routine focuses on updating the supply utilization account (SUA) of the revised item using the newly available data. The following actions are performed:

- Re-computation of seed and losses based on the updated supply values.
- Re-balancing of the SUA equation through proportional balancing techniques.
- Re-computation of nutritive factors, specifically for the revised food variable.
- Re-calculation of total DES, incorporating the newly computed nutritive factors for the updated item.

- Notification to analysts via email, which includes a set of outputs intended for validation of the results.

Re-computation of seed and losses

Whenever there is a change in supply, it is necessary to re-calculate the seed and losses variables. This is because both are determined by applying fixed ratios to supply values. Specifically, losses are calculated as a ratio over production and imports, while seed is calculated as a ratio over production.

Let:

X = Production

I = Imports

L = original Losses

S = original Seed

Define the *fixed ratios* (computed from the original data):

Loss ratio:

$$r_L = \frac{L}{X + I}$$

Seed ratio:

$$r_S = \frac{S}{X}$$

Now suppose Supply (and possibly Production / Imports) changes after balancing. Let:

- X^{new} = updated Production
- I^{new} = updated Imports

New Losses

$$L^{new} = r_L \cdot (X^{new} + I^{new})$$

New Seed

$$S^{new} = r_S \cdot X^{new}$$

Proportional balancing

After the revision of one or more variables and the consequent adjustment of losses and seed using fixed ratio, the single-tree algorithm performs a proportional balancing on all the unprotected variables. This means that if the SUA equation with the new data is unbalanced, the computed residual will be proportionally re-distributed to all the estimated variables using weights based on that variable original relative magnitude.

Let:

- i index observations in the selected item-year combination
- V_i = original Value
- $P_i \in \{0,1\}$ = 1 if *Protected*, 0 otherwise
- R = total imbalance to distribute

1. Compute total value of unprotected utilizations (excluding losses and seed)

$$T = \sum_{j \in \{i: P_i=0\}} V_j$$

2. Compute proportional weights

$$w_i = \frac{V_i}{T}, i \in \{i: P_i = 0\}$$

3. Adjust values by distributing imbalance, applying a non-negativity constraint

For each unprotected element:

$$V_i^{new} = \max(0, V_i + w_i R)$$

Case: processed revised = TRUE

When the parameter `processed_revised` is set to TRUE the single tree algorithm performs the same steps as the previous case, but also revises the allocation to food processing. After that, starting from the newly updated food processing, the algorithm goes on to update production of unprotected derived items.

The routine follows three different scenarios:

Scenario 1: all the derived products are protected: the routine will stop and send an email to the analyst to check data

Scenario 2: At least one derived product is unprotected:

If there are some derived products with protected production and at least one with unprotected production the single tree algorithm recalculates the unprotected production data based on the updated parent item food processing variable, taking into account the quantity necessary to produce the protected derived items.

To ensure that the food processing quantity is enough to cover production of all derived products, the single-tree algorithm calculate minimum food processing as the quantity required to produce all protected derived items.

$$\text{Minimum food processing} = \sum_{i:P_i=1} X_i \frac{s_i}{e_i}$$

Where s_i = down share; e_i = extraction rate

After calculating minimum quantity required for food processing, the algorithm verifies whether the new allocation for food processing, which is based on the updated supply, meets or exceeds this minimum requirement. If it does not, the process should be halted and the analyst is notified. If the new exceeds the minimum, the algorithm recalculates the up-processing shares for protected derived items using the new food processing value, and adjusts the up-processing shares for unprotected derived items proportionally according to their previous shares. At this point, the single-tree algorithm can compute the new production levels for unprotected derived items by multiplying the new food processing value by the new up-processing shares and the extraction rates, as:

Let:

X_i^{new} = new production of child i

V^{new} = new food processing value

s_i^{new} = new up-processing share for child i

Then, for unprotected derived items:

$$X_i^{new} = V^{new} \cdot s_i^{new} \cdot e_i, i \in \{i: P_i = 0\}$$

After adjustment of production, the unprotected derived items SUAs will require proportional balancing, with the same approach outlined in the session above.

Finally, if the item involved in the adjustments have co-products, the algorithm updates the production figures for co-products and ensures their SUAs are balanced accordingly.

Scenario 3: All derived items are unprotected

When all the derived products are estimated, the single-tree algorithm simply calculates the new food processing value based on the updated supply. Then, it uses the up-processing shares to determine the new production of derived items by multiplying the new food processing value by the corresponding processing shares and extraction rates. Then it performs proportional balancing among the derived items, ensuring that this step does not alter their food processing variable. Finally, the single tree algorithm updates the production figures for any co-products accordingly and balances their SUAs to reflect these changes.

For all three scenarios, after the adjustments and balancing the algorithm re-computes nutritive factors, re-compute aggregates (DES) and send output files for validation of results.

4. Section 4: A practical example

A typical application of the Single-tree algorithm occurs when newly available official statistics for a given country and commodity (e.g., data provided by the National Statistics Office) differ substantially from the previously used estimates in the national SUA. The following scenario describes the steps implemented by the algorithm to ensure consistency with the SUA framework when incorporating the new information, including the associated revision procedures.

For example, consider paddy rice and its associated derived products. In this simplified case, it is assumed that only two products are obtained from the primary item paddy rice in the country under consideration: husked rice and rice milled.

The production value for paddy rice is revised upward, as reported by the national statistical office, resulting in an increase of about one hundred thousand tonnes (see Figure 5).

Figure 4. Original SUA for paddy rice

Item	SUA variable	Value	Protected
Paddy rice	Opening Stocks [t]	-	-
	Production [t]	196,245,700	1
	Import [t]	1,000	1
	Stock Variation [t]	-	-
	Export [t]	460,635	1
	Feed [t]	12,313,244	0
	Seed [t]	3,275,491	1
	Loss [t]	5,196,330	1
	Food processing [t]	175,000,000	0
	Residual other uses [t]	-	-

Figure 5. Step 1: revision of production data and update of seed and losses

Item	SUA variable	Value	Protected
Paddy rice	Opening Stocks [t]	-	-
	Production [t]	300,000,000	1
	Import [t]	1,000	1
	Stock Variation [t]	-	-
	Export [t]	460,635	1
	Feed [t]	12,313,244	0
	Seed [t]	5,007,230	1
	Loss [t]	7,943,595	1
	Food processing [t]	175,000,000	0
	Residual other uses [t]	-	-

The single tree algorithm begins by recalculating seed and losses based on their respective ratios over supply and the updated production value. Seed is determined using a 2% ratio, while losses are calculated with a 3% ratio (step 1).

In the step 2, the algorithm balances the paddy rice SUA by adjusting unprotected variables, specifically feed and food processing. The new residual to be allocated is first determined, followed by computing the weights of each variable according to their share on total unprotected utilizations (see Figure 6). Based on these calculations, the residual is distributed among unprotected variables, resulting in a balanced SUA equation (Figure 7).

Figure 6. Distribution of residual

Computed residual to be allocated	99,276,295
Total unprotected utilizations	187,313,244
Weight of feed over total utilization	0.07
Weight of processed over total utilizations	0.93

Figure 7. Step 2: balancing paddy rice SUA

Item	SUA variable	Value	Protected
Paddy rice	Opening Stocks [t]	-	-
	Production [t]	300,000,000	1
	Import [t]	1,000	1
	Stock Variation [t]	-	-
	Export [t]	460,635	1
	Feed [t]	18,839,282	0
	Seed [t]	5,007,230	1
	Loss [t]	7,943,595	1
	Food processing [t]	267,750,257	0
	Residual other uses [t]	-	-

Following step 2, the primary item has been modified. As a result of changes to the quantity allocated to food processing, the production of derived products should be adjusted. In this example, there are two derived products: husked rice and milled rice. Of these, the production of milled rice is official and remains fixed. Consequently, the algorithm will adjust the output of husked rice, factoring in both the updated food processing and the quantity of milled rice produced (see Figure 8).

Figure 8. Paddy rice tree: derived products

Item	SUA variable	Value	Protected
Husked rice	Opening Stocks [t]	-	-
	Production [t]	717,500	0
	Import [t]	350	1
	Stock Variation [t]	-	1
	Export [t]	16,165	1
	Food [t]	701,685	0
	Residual other uses [t]	-	-
Milled Rice	Opening Stocks [t]	34,000,000	1
	Production [t]	116,141,375	1
	Import [t]	11,431	1
	Stock Variation [t]	1,000,000	1
	Export [t]	17,866,082	1
	Food processing [t]	5,830,000	0
	Food [t]	91,456,724	0
Residual other uses [t]	-	-	

Figure 9 represents the simplified commodity tree for paddy rice. The table reports the conversion factors and the shares of food processing dedicated to each derived product.

Based on this information, it is possible to estimate how much food processing is needed to produce milled rice (whose production is official) and consequently determine the updated portion of food processing that can be allocated to husked rice production (Figure 10).

Figure 9. Tree parameters of paddy rice tree

Parent item	Derived item	Extraction rate	Up-processing share	Down share
Paddy rice	husked rice	0.82	0.005	1
Paddy rice	milled rice	0.67	0.995	1

Figure 10. Computation of new up-processing share

Processed from protected derived items	174,125,000
Share of protected derived items	0.65
New share to be allocated among unprotected derived items	0.35

The single-tree algorithm now moves to step 3 to calculate husked rice production by multiplying the food processing amount with the updated share and extraction rate, resulting in about 77 million tonnes (see Figure 11).

Figure 11. Step 3: adjusting production of derived according to the new food processing

Item	SUA variable	Value	Protected
Husked rice	Opening Stocks [t]	-	-
	Production [t]	77,192,281	0
	Import [t]	350	1
	Stock Variation [t]	-	1
	Export [t]	16,165	1
	Food [t]	701,685	0
	Residual other uses [t]	-	-

Once the new production is created, the SUA for husked rice must be re-balanced. Since food is the only unprotected variable in this case, a weight of 1 will be applied to its allocation of the residual, and the food value will be adjusted accordingly (see Figure 12).

Figure 12. Balancing the adjusted derived product

Item	SUA variable	Value	Protected
Husked rice	Opening Stocks [t]	-	-
	Production [t]	77,192,281	0
	Import [t]	350	1
	Stock Variation [t]	-	1
	Export [t]	16,165	1
	Food [t]	77,176,466	0
	Residual other uses [t]	-	-

5. Conclusions

This paper examined, within the framework of Supply and Utilization Account (SUA) compilation, the methodological approach and practical application of the Single-tree algorithm recently

developed by the FAO CLFS Team. The algorithm is designed to address certain limitations inherent in the traditional compilation procedure.

Under the standard framework, SUA compilation is performed simultaneously across all commodity trees and embedded parameters (i.e., extraction rates and processing shares) of the dataset, relying on a coordinated adjustment of supply and utilization elements for a given country and reference period. The decision to adopt the Single-tree algorithm must therefore be based on a case-specific cost–benefit evaluation and requires a rigorous ex-ante assessment to avoid introducing structurally inconsistent or unsustainable adjustments. A clear trade-off exists between the use of the Single-tree approach and the standard SUA balancing procedure. When modifications to the item under analysis propagate extensively across related items or commodity trees, generating widespread adjustments, adherence to the original coordinated workflow may constitute the more efficient and methodologically appropriate solution.

The analysis provides a formal mathematical demonstration that the adoption of the Single-tree algorithm enables the adjustment of an individual SUA item or commodity tree allowing specific SUA components to be treated independently, without inducing automatic changes in interconnected commodity trees for the desired time range. By construction, the algorithm supports the targeted revision of previously compiled SUA datasets and allows fast and agile revision of SUAs otherwise time consuming.

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