Strengthening National Capacity for Food Balance Sheet Compilation: The Role of the FAO FBS Shiny Application

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1. Background and Motivation

Reliable and timely food system data are a prerequisite for effective food and agricultural policy. Governments designing interventions to address food insecurity, reduce import vulnerability, improve nutritional outcomes, or allocate agricultural investment require a comprehensive quantitative picture of how food is produced, traded, and consumed within their borders. Among the statistical instruments available for such analysis, the Food Balance Sheet (FBS) occupies a uniquely central position.

An FBS is a national accounting framework presenting a comprehensive picture of food commodity flows over a reference period — from domestic production and imports, through competing uses including animal feed, seed, industrial processing, and post-harvest losses, to quantities available for human consumption. By applying nutrient conversion factors to these food availability figures, the FBS also yields estimates of dietary energy supply (DES), protein availability, and fat availability per capita per day. The FBS data also plays a key role in enabling the monitoring of undernourishment at the national and global level, including under Sustainable Development Goal (SDG) 2.[1]

The Food and Agriculture Organization (FAO) of the United Nations compiles FBS annually for over 190 countries, and the global FBS dataset has underpinned numerous studies on agricultural development, food security, dietary health, and trade.[2][3][4] However, despite FAO's global compilation, there remains a pronounced need for national-level FBS compilation.

The case for national FBS compilation rests on at least three arguments. First, given the central importance of the FBS to food and agricultural policy, it should be treated as a core component of the national statistical system. This means it must be institutionally owned, regularly updated, and fully integrated into the country's statistical architecture for monitoring its food and agricultural system. The second argument concerns data quality and the value of local knowledge. FAO compiles global FBS primarily from data reported through official international channels such as questionnaires, UN Comtrade, and related sources. National statistical offices often possess better and more granular data that do not enter the international reporting pipeline in time. By compiling their own FBS, national institutions can integrate this locally available data, achieving greater accuracy than is possible using only international datasets.

Third, national food systems are highly diverse, and the global FBS framework may overlook important aspects unique to each country. A striking illustration of this limitation emerged during the pilot implementation of the FBS Shiny Application in Guatemala. Tortillas - the dominant staple food in Guatemala, consumed daily across virtually all socioeconomic groups and accounting for a substantial share of total caloric intake - do not appear in the global commodity tree, which follows the international CPC classification structure. When the Guatemala team compiled their own FBS using the application, this gap became immediately apparent. National compilation thus not only produces more accurate national estimates but also surfaces gaps in the global framework that drive its continuous improvement.

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Despite the strong rationale for national-level FBS compilation, most national statistical offices in low- and middle-income countries (LMICs) have found independent FBS compilation to be practically inaccessible. The revised FAO FBS methodology, which involves complex processes such as statistical imputation to address missing data, rules-based balancing of supply and utilisation, and standardisation of commodity accounts to their primary equivalents through processing trees, is technically demanding.[5] It is implemented in the R programming language[6] and demands not only programming proficiency but also a deep understanding of the statistical assumptions that underpin each analytical module.

Many national analysts possess substantial domain expertise regarding their food systems; however, their exposure to programming and advanced statistical techniques is often limited. This lack of technical capacity creates a significant barrier to adoption, which has proven insurmountable without sustained technical support. Unfortunately, few countries have consistent access to such support, leaving the gap in national FBS compilation largely unaddressed.

This capacity gap is part of a broader challenge in agricultural statistics in the developing world. The African Development Bank's systematic assessment identifies widespread deficits in institutional infrastructure, human resources, and statistical methods across African national statistical systems.[7] The 50x2030 Initiative - a multi-partner programme involving FAO, the International Fund for Agricultural Development (IFAD), and the World Bank - was established specifically to close the global agricultural data gap.[8] Existing capacity building initiatives have made genuine contributions, but focused primarily on data collection, improving how countries gather raw data, rather than on the compilation and analysis needed to transform data into coherent statistical products.[9][10] The specific gap in FBS compilation tools has remained largely unaddressed.

This paper presents the FAO FBS Shiny Application, which is a web-based platform that deploys FAO's full revised FBS methodology through an accessible graphical interface. The paper makes three contributions: first, a detailed account of the application's statistical and algorithmic architecture, showing how complex multi-stage compilation has been made accessible without sacrificing rigour; second, pilot evidence demonstrating the extent to which national compilation using the application improves the accuracy and relevance of FBS estimates; and third, it considers the implications of a shared compilation platform for strengthening both national statistical systems and the global agricultural data architecture.

2. The FAO FBS Shiny Application

Development History and Architecture

The Shiny framework[11], developed by RStudio, allows statistical programmes written in R to be deployed through a web-based graphical interface. This eliminates the necessity for users to interact directly with code, thereby lowering the technical barrier for national analysts and facilitating broader adoption of the application.[12]

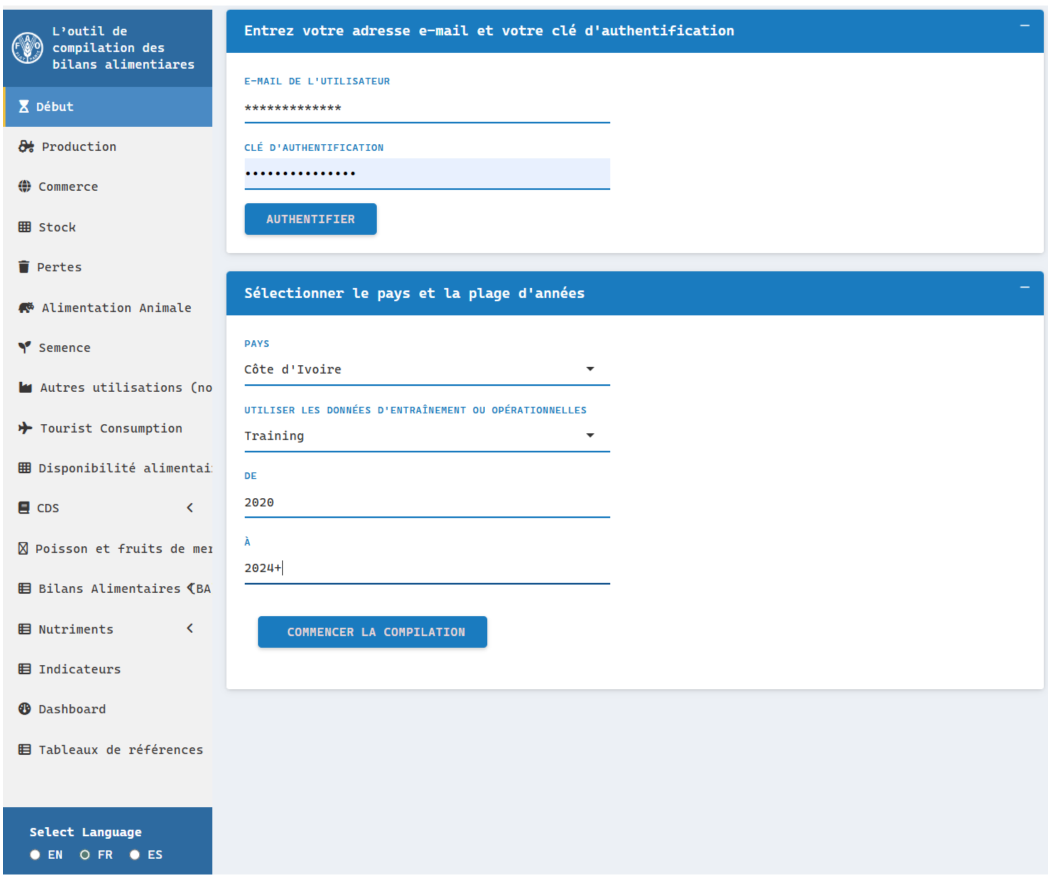
The FBS Shiny application was initially developed in 2017 as an R-Shiny project, requiring users to have R and all relevant packages installed locally. It was subsequently repackaged as a “Dockerized” desktop solution, which eliminated installation dependencies. This version of the application was used by a number of countries across multiple regions, including Sri Lanka, Mongolia, the Philippines, Jordan, and Bangladesh in Asia; Benin, Côte d'Ivoire, Guinea, Comoros, Mali, and Mozambique in Africa; Kazakhstan in Central Asia; and, Panama and Uruguay in Latin America.

However, the application still had two major operational limitations. It imposed hardware prerequisites, including minimum RAM and processor speed that could not always be guaranteed, with users whose machines fell below the required specifications experiencing significantly degraded application performance. Second, it lacked real-time data synchronization, meaning that changes made by one user were not visible to others working concurrently on the same dataset, creating risks of data inconsistency.

In 2025, the application was deployed online on a central server, removing local hardware dependencies entirely and enabling full synchronisation across all users within a country. The application can now be accessed through any standard web browser. Security and data integrity are maintained through password-based authentication, with each users' access restricted to specific country data.

Another key advantage of centralised hosting is that it guarantees all countries operate with the same, up-to-date version of the FBS methodology. Any algorithmic improvements or methodological updates are implemented centrally and become available to every country simultaneously. This approach ensures a level of methodological consistency and standardisation that is difficult to achieve with script-based or locally installed solutions. To accommodate the geographic and linguistic diversity of its user base across Africa, Asia, and Latin America, the application is made available in English, French, and Spanish. This multilingual support is crucial for effective capacity building and widespread adoption across different regions.

Fig. 1. Application authentication screen and country selection interface (with French as interface language).



The application's workflow follows the logical sequence of FBS compilation, guiding users through data entry, imputation, balancing, standardisation, and analysis. Each stage is accessible through a clear navigation structure organised around the domain structure of the Supply Utilisation Accounts (SUAs), with separate modules for production, trade, stocks, food consumption, feed, seed, industrial use, losses, processing, and tourist consumption.

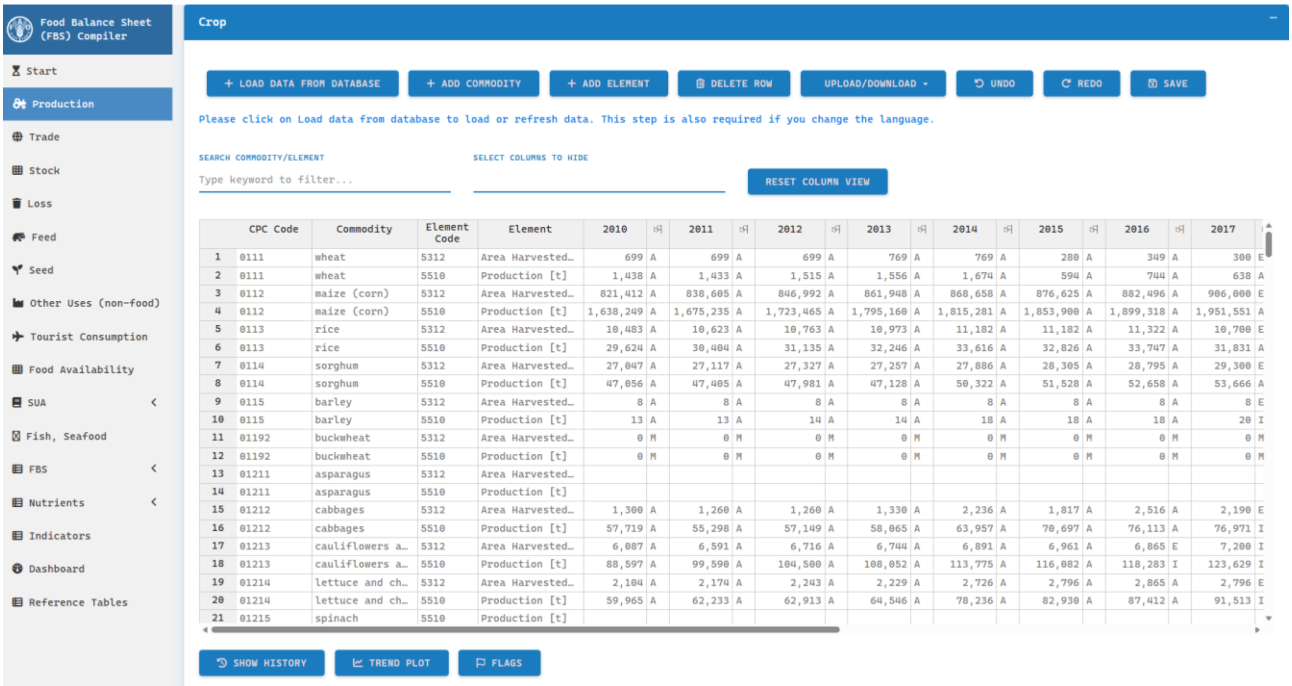
Data Entry, Management, and the Flags System

Within each domain, data are shown in a tabular format that is familiar to anyone who has used spreadsheets. Analysts can easily update values by double-clicking any cell. They can also add new commodity rows or remove existing ones, making data management straightforward. For any commodity, the application allows users to view time series trends directly in the interface, enabling continuous checks on data quality.

The application fully supports two-way data exchange with Excel. This means any dataset in a domain can be downloaded as an Excel file, modified externally, and then re-uploaded; all changes will be automatically updated in the application. This feature is particularly useful for collaborative work, where different team members or departments may be responsible for different parts of the supply-utilisation data.

Importantly, every change made within the application is automatically recorded in a detailed change history. This log captures the original value, the new value, the date of the change, and the user who made it. Such an audit trail is essential for maintaining high standards of statistical governance and ensuring data quality.

Fig. 2. Data entry interface showing production domain structure



One of the most conceptually significant innovations is the application's comprehensive data flags system, which records the source and methodological basis of every data value. The system distinguishes between official and non-official statistics and, within official statistics, identifies four data production methods: surveys, censuses, administrative records, and remote sensing. These flags are applied not only to production data but to every domain including trade, feed use, loss coefficients, and food consumption. At the national level, flags provide a structured data quality assessment of each country's agricultural statistical system. At the global level, as more countries compile their data using the application, the accumulated flags form a comprehensive metadata layer that documents how agricultural statistics are produced across the countries. This provides tangible evidence that is currently available only in fragmented and mainly qualitative forms and that can be directly used to inform the targeting of capacity-building initiatives.

Imputation of Missing Data

A persistent challenge in compiling national Food Balance Sheets (FBS) is the presence of incomplete data across commodities, utilisation categories, and different time periods. To address this issue, the application incorporates a structured imputation framework designed to fill these gaps systematically. The application supports imputation for several key variables, including stock variations, post-harvest losses, and food consumption quantities. Each variable is handled using a robust, tailored approach appropriate to its characteristics.

For instance, when imputing food consumption values, the process begins by deriving the available quantity for each commodity and reference year. This is calculated from the supply-utilisation identity, taking the residual of production, trade, stocks, and all non-food utilisations. For commodities where food consumption is the sole meaningful utilisation, termed "food residual items", the imputation is straightforward: food consumption is set equal to the food-available supply. In contrast, for non-residual commodities, the application employs a dynamic demand estimation method. This approach updates food consumption estimates from the past based on population change, real GDP per capita growth, commodity-specific income elasticity of demand, and a configurable functional form that governs the income-demand relationship. Elasticity and other parameters in the imputation model are externally specified and can be adjusted by country analysts providing flexibility for country-specific calibrations.

The Balancing Algorithm

The balancing algorithm ensures that the total supply and utilisation for every commodity and each year match perfectly. To do this, it uses past compiled data (from 2000 to 2013) to understand typical usage patterns and what kinds of adjustments are reasonable. The algorithm balances each year in sequence in mainly four steps:

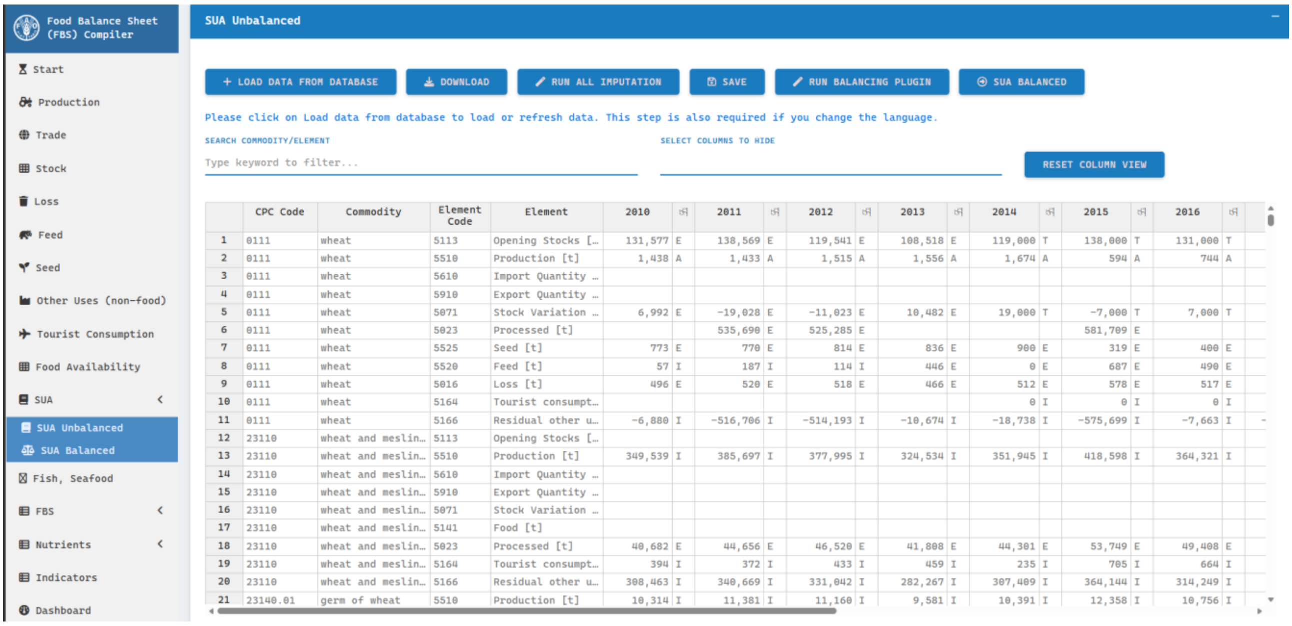
1. Identify residual utilisation items: For commodities with a clear main usage, any imbalance is simply assigned to this dominant category. For example, when compiling data for cottonseed cake, if there is an imbalance between supply and utilisation, the algorithm will assign the residual quantity to the feed category, since it is the only meaningful utilisation for this commodity. In cases where the imbalance is negative, the algorithm proportionally reduces utilisation, ensuring all values remain non-negative.
2. Proportional redistribution: For the remaining commodities, imbalance is distributed across several relevant utilisation categories. This redistribution is based on historical usage shares observed in the 2000–2013 period.
3. Iterative adjustment: The algorithm recalculates imbalances and continues adjusting until the supply and utilisation are fully balanced, or until it reaches limits set by the historical data.
4. Final adjustment for small imbalances: If there are very minor imbalances (less than ±5% of total supply), the algorithm temporarily relaxes its rules to clear them.

The algorithm runs automatically when prompted and shows a complete before-and-after comparison for each commodity. This allows analysts to review all adjustments, and if needed, manually override them using their own expertise.

Standardisation and Aggregation

Following balancing, a standardisation procedure converts commodity-level SUAs into the final FBS by expressing all commodity quantities in primary equivalents through a commodity processing tree, that is, mapping every derived product back to its parent commodity using extraction rates and processing shares. The application handles complex commodity relationships including multiple-parent commodities, multiple-child parents, and zero-weight by-products, aggregating consistently across multiple FBS group hierarchy levels.

Fig. 3: Consolidated SUA *data with residuals and providing an option to perform balancing via a dedicated button.*



The commodity processing tree is fully editable within the application. National teams can modify extraction rates to reflect local processing technology. The application similarly allows modification of nutrient conversion factors, enabling countries with national food composition tables to replace global defaults with locally validated values. This is particularly significant for countries with distinct food cultures and endemic crop varieties whose nutritional properties differ from global averages.

The processes outlined above — imputation, balancing, and standardisation — together form a highly complex statistical system. The application executes all this reliably behind a browser-based interface, accessible without any software installation, and without programming knowledge. In doing so, it preserves the full rigour of FAO's validated methodology while ensuring methodological consistency across all national users through centralised deployment. This represents a contribution to agricultural statistics infrastructure that extends well beyond the design of a user-friendly tool.

3. Evidence from Pilot Implementation

The application has been piloted in five countries spanning three geographic regions — Bhutan (South Asia), Mauritius (Indian Ocean), Eswatini and Angola (Sub-Saharan Africa), and Guatemala (Latin America) — and is currently in active use in several other countries. This geographic spread includes small island developing states, landlocked economies, and large resource-rich nations with significant data gaps. The following subsections present detailed case studies from Bhutan and Guatemala, which most clearly illustrate that national compilation generates insights and accuracy improvements over globally compiled figures.

Bhutan — Supply Chain Intelligence and Utilisation Classification

Bhutan's food system is characterised by high structural import dependency, with a large proportion of national food requirements met through imports, the overwhelming majority sourced from India. This configuration, characterised by a concentrated importer base and a limited number of principal trading entities, presented a valuable methodological opportunity.

The Bhutan national team identified an extremely granular approach to determine the pattern of utilization of major commodities. Since Bhutan is a highly import dependent country, the team used identity of importing entity and the business activities of the importing entity, to infer the nature of utilization of quantity imported by it. If maize is imported by a commercial feed manufacturer, it was allocated to use as feed while maize imported by a distillery was allocated to use for production of alcohol. Because Bhutan's major commodity importers are relatively few and their operational profiles can be understood by national compilers, this approach allows for better estimation of utilisation. Such an approach produces utilisation estimates grounded in empirical supply chain intelligence, reflecting the actual deployment of commodities within the national context. This kind of detailed empirical work can only be done by technical experts in National Statistical Offices.

This can be generalised to other aspects of utilization as well. National experts have access to information about the structure of industry and supply chains and can use these for better estimation of the pattern of utilization of food commodities.

Guatemala — Commodity Tree Extension and the Tortilla Case

Guatemala's pilot produced the most methodologically significant findings across all five implementations. Tortillas — flat, unleavened bread made from maize — are the central staple food of Guatemala, consumed daily across virtually all socioeconomic groups and accounting for a dominant share of national caloric intake. They do not, however, appear in FAO's standard global commodity tree, which uses the international CPC classification of commodities.

The practical consequence is significant. In FAO's global FBS, maize not accounted for in other utilisation categories flows to food in its grain or flour form, with dietary energy calculated using nutrient coefficients for those commodity forms. However, when maize is processed for foods like tortillas — which are the main staple in Guatemala — its nutritional content changes. These processes can affect how many calories it provides, improve the quality of its protein, and alter the amounts of important nutrients such as calcium. If a country's main way of consuming maize is through tortillas, simply treating it as raw grain in the balance sheet would result in inaccurate nutritional estimates for the population's diet.

When the Guatemala national team used the application to compile their FBS, the process itself surfaced this gap — the absence of tortilla from the global commodity framework became immediately apparent when national compilers engaged with their own food system data. This finding opened a collaborative dialogue between the national team and FAO to address the gap through appropriate modification to the CPC classification. This dynamic — national compilation as a mechanism for identifying gaps in the global statistical framework that would otherwise remain invisible — is one of the most significant benefits of the tool, demonstrating how the application fosters collaboration between national statistical offices and FAO that drives continuous improvement of the global agricultural statistics system.

Cross-Cutting Lessons from Pilot Implementation

The pilot implementations reveal several lessons that cut across all experiences. First, compiling data at the national level uncovers insights that are simply not accessible from international datasets alone; the case studies show that local compilation offers a deeper understanding of supply chain structures, consumption patterns, and trade positions that centralised systems cannot provide. Second, close collaboration among different national agencies, such as ministries of agriculture, statistical authorities, customs, and livestock departments, proves to be just as crucial as technical knowledge. The structure of the application and its audit features directly help address this coordination challenge. Third, the use of the flags system offers immediate benefits for diagnosis: applying flags across different data domains in all pilots brought to light valuable information about data quality and production practices that was not previously available in an organised way, thus highlighting areas where capacity building should be prioritised.

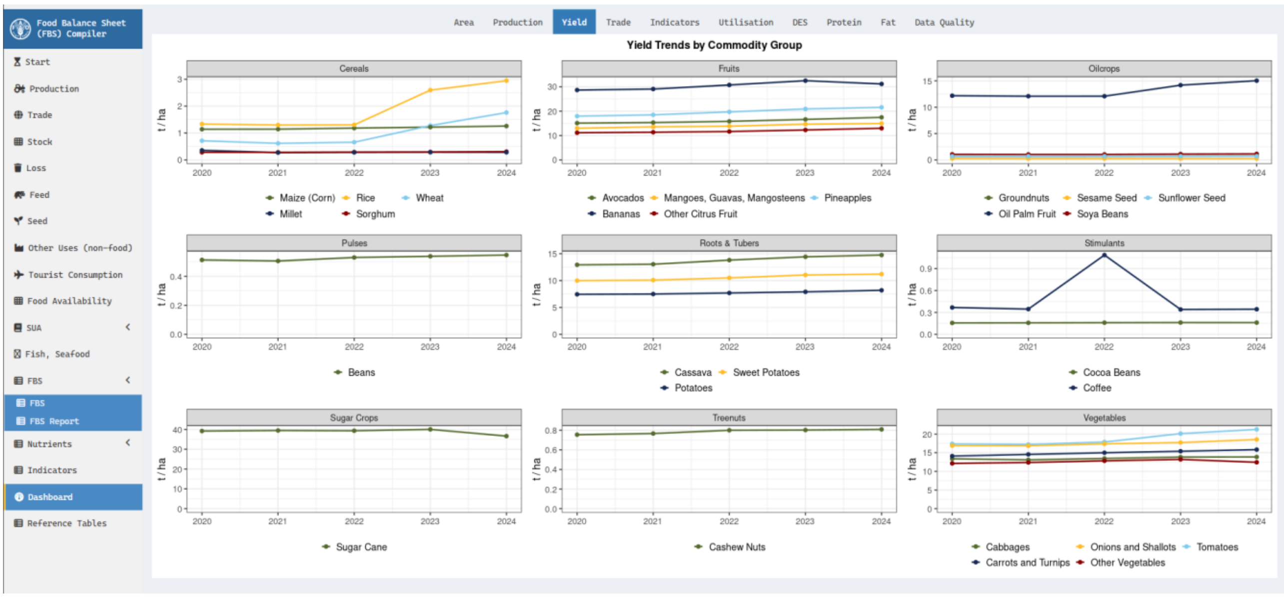
4. Policy Insights from the Application Dashboards

A fundamental design principle of the FBS compiler application is that compilation and analysis are integrated within a single platform. Once balancing and standardisation are complete, the application automatically generates a comprehensive suite of policy-relevant indicators and visualisations derived consistently from the compiled data, requiring no additional analytical work or separate software. This integration ensures complete consistency between the balance sheet and every derived indicator and makes policy-relevant analysis accessible to the same national analysts who compiled the data, without requiring a separate cadre of economists or data scientists to interpret results.

Agricultural Production and Productivity

The production module presents trends in area harvested and output for individual commodities and groups, alongside yield trends which are the primary measure of agricultural productivity. A particularly valuable feature is benchmarking of national yields against regional and global averages at the individual commodity level. This benchmarking identifies commodities where domestic productivity is competitive and those where a significant yield gap exists relative to regional peers, directly informing prioritisation of agricultural investment. Growth rate indicators for output across commodity groups further distinguish commodities with consistent production growth from those experiencing volatility or long-term decline — essential context for national food security planning.

Fig. 4: Agricultural Productivity dashboard: yield trends of major crops in Angola



Trade Analysis in Primary Commodity Equivalents

The trade module is one of the most analytically powerful dashboard outputs. Agricultural trade data are inherently disaggregated — recorded at the level of individual commodity codes — which creates a structural analytical problem: a country's true net trade position in any commodity cannot be assessed when that commodity is traded simultaneously in raw and processed forms. The FBS compilation resolves this by converting all trade flows to primary commodity equivalents through the processing tree, providing an accurate picture of net trade positions across the full breadth of traded forms.

The Bhutan pilot illustrates its importance. Bhutan exports a significant quantity of beer, appearing in disaggregated statistics as an agricultural export. However, beer production depends on imports of both malt and maize as primary inputs. When the application aggregates trade to primary commodity equivalents — converting beer exports to their grain and malt equivalents and netting against raw material imports — Bhutan's apparent export strength is revealed as structural import dependency: in primary equivalent terms, the country is a net importer in this supply chain, not a net exporter. This insight is entirely invisible in disaggregated data and has direct strategic implications: a government promoting beer export growth without awareness of the underlying raw material dependency risks deepening a structural vulnerability rather than building genuine domestic agricultural value.

Self-Sufficiency and Import Dependency

The dashboard presents food self-sufficiency ratios and import dependency ratios at both commodity and commodity group levels. Group-level indicators give policymakers an overview of which broad food categories are domestically supplied and which depend on international markets; commodity-level indicators provide the granularity needed for targeted policy design — a country may appear self-sufficient in cereals as a group while being heavily import-dependent in wheat specifically. Trend monitoring of these indicators provides a direct measure of whether import substitution or food security policies are achieving intended effects.

Utilisation Structure

The utilisation dashboard presents the distribution of available food commodities across competing uses — human food consumption, animal feed, seed, industrial processing, and post-harvest losses — for each commodity group. For policymakers, this distribution reveals how the national food system allocates its available resources and where systemic inefficiencies may exist. A commodity group where a large share of availability is absorbed by post-harvest losses signals an opportunity for efficiency gains without requiring any increase in production. Where a growing proportion of a commodity is being diverted from food to industrial or feed uses against a backdrop of rising food insecurity, the utilisation breakdown surfaces a potential policy tension that aggregate supply indicators alone would obscure.

Dietary Indicators

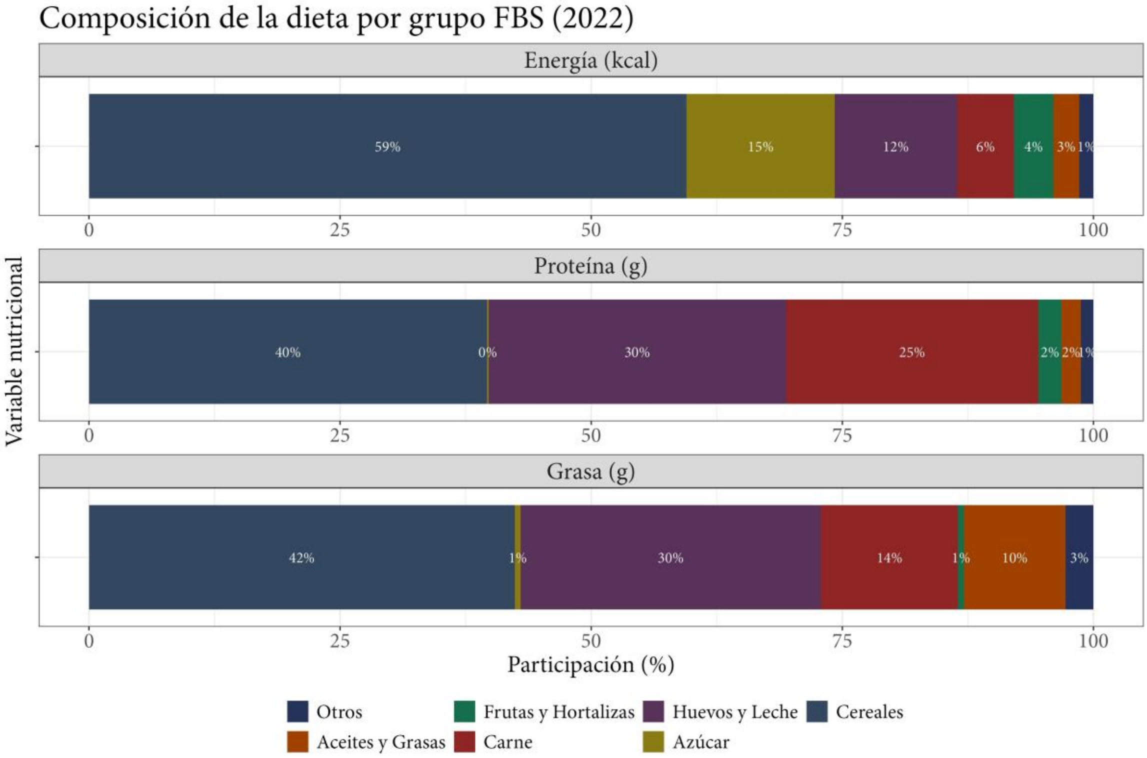
The dietary indicators module translates food consumption estimates into nutritional outcomes directly relevant to public health and SDG monitoring. The dashboard presents DES trends — the trajectory of kilocalories available per capita per day — and its composition by commodity group, showing which foods contribute most to the national caloric base and how this has changed over time. Equivalent analysis is provided for protein and fat availability. The application also generates a dietary diversity assessment based on commodity group composition, flagging situations where the caloric base is highly concentrated — a risk indicator that is directly relevant to nutrition policy design.

5. Toward a Cooperative Global Agricultural Data Infrastructure

The preceding sections have presented the FBS Shiny Application primarily from a national perspective. However, the architecture of the application has implications that extend beyond individual country compilations, creating the foundations of a cooperative global infrastructure for agricultural statistics built from the bottom up.

The application leverages a centralised hosting model, unified methodology, structured metadata, and country-specific configuration options. This enables national statistical teams to compile their own Food Balance Sheets (FBS), identify and address data gaps, and improve their estimates using the most accurate local evidence available. By returning these improvements to the FAO's global system, countries directly contribute to raising the quality and accuracy of international food statistics. The conventional capacity building model is top-down; the application creates a bottom-up dynamic where national compilation improves the global system directly.

Fig. 5. Dietary composition visualisation produced in the application — commodity group wise composition of energy, protein and fat per capita (in Spanish)



Another core advantage of the application is its ability to resolve the persistent challenge of inconsistent methods and classifications that have historically made cross-country comparisons unreliable. The application distributes a standardised methodology to all participating countries. Core algorithms for balancing, imputation, and standardisation are shared, while countries retain the flexibility to adjust commodity and nutritional parameters to fit their local context. This approach achieves a balance between national specificity and international comparability, ensuring that each country's data is both contextually accurate and globally consistent.

The flags system takes on additional significance at the global scale. As national compilations accumulate, the flags constitute a global metadata layer documenting how agricultural statistics are produced across the diversity of national systems. This evidence provides a principled basis for targeting capacity building investments: programme designers can identify specifically which domains and commodity groups in which countries lack direct measurement. Changes in flags distributions over time provide a measurable indicator of progress in statistical capacity that currently has no reliable global instrument.

In the future, the aim is for the application to play an important role in the production and analysis of agricultural data globally. National statistical offices would contribute their locally validated data, improving both their own analytical capacity and the quality of global statistics. However, fully realizing this potential will require further investment in scaling up the platform and extending the system to more countries, particularly in Sub-Saharan Africa and other least developed regions where policy needs are highest and current statistical infrastructure is weakest.

6. Conclusions

The application's integrated policy dashboard transforms the FBS from a statistical product into a decision-support instrument, automatically generating indicators on productivity, trade structure in primary commodity equivalents, self-sufficiency, utilisation patterns, dietary energy supply, and data quality.

Pilot implementations in five countries demonstrate that the application delivers accessibility without sacrificing accuracy — and in critical respects produces estimates more accurate than centralised compilation can achieve. The Bhutan national team's classification of commodity imports by importer identity replaced regional average imputation with direct supply chain observation. In Guatemala, the process of national compilation itself surfaced the absence of tortilla from the global commodity framework, prompting collaborative dialogue with FAO to address it — demonstrating that national compilation not only improves national estimates but also drives improvement of the global statistical framework. These are not isolated technical successes: they are evidence that national compilation, facilitated by the right platform, mobilises local knowledge and strengthens the global agricultural statistics system from the bottom-up.

Looking ahead, the application's development priorities encompass expanding language support to better serve a diverse user base, and enhancing imputation methods for greater statistical robustness. Additionally, the strategy aims to extend the platform's accessibility to least developed country contexts, particularly where policy needs are critical and current statistical capacities are limited.

Overall, the FBS Shiny Application represents a significant and practical contribution to making rigorous agricultural statistical methodology accessible to the national institutions that need it most, advancing simultaneously the national food security monitoring capacity of individual countries and the collective statistical infrastructure on which global food system understanding depends.

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