Guidelines for the Compilation of Food Balance Sheets

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Acronyms

AFZ	French Association for Animal Production (Association Française de Zootechnie)
AGA	Mexican Customs General Administration (Administración General de Aduanas de Mexico)
AGMEMOD	Agriculture Member States Modeling
AMIS	Agricultural Market Information System
CILSS	Permanent Interstates Committee for Drought Control in the Sahel (Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel)
CIRAD	French Agricultural Research Centre for International Development (Centre de Coopération Internationale en Recherche Agronomique pour le Développement)
CPC	Central Product Classification
DDGS	Distiller's Dried Grains with Solubles
DES	Dietary Energy Supply
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FBS	Food Balance Sheet
FCL	FAOSTAT Commodity List
FEWS NET	Famine Early Warning System Network
FUSIONS	Food Use for Social Innovation by Optimising Waste Prevention Strategies
g	Gram
GDP	Gross Domestic Product
GIEWS	Global Information and Early Warning System
GS	Global Strategy to Improve Agricultural and Rural Statistics
HA	Hectare
HS	Harmonized System
ICBT	Informal Cross Border Trade
ICEC	Interagency Commodity Estimates Committee
IDR	Import Dependency Ratio
IFPRI	International Food Policy Research Institute
INFOODS	International Network of Food Data Systems
INRA	French National Institute for Agricultural Research (L'Institut National de la Recherche Agronomique)
INTERFAIS	International Food Aid Information System
kcal	Kilocalorie

L	Liter
MAFW	Indian Ministry of Agriculture & Farmers Welfare
METIS	Joint UNECE/Eurostat/OECD Work Session on Statistical Metadata
MT	Metric Tonne
Nes	Not elsewhere specified
NCT	Nutrient Conversion Table
NSO	National Statistics Office
OCE	Office of the Chief Economist
OECD	Organisation for Economic Cooperation and Development
PoU	Prevalence of Undernourishment
PS&D	Production, Supply and Distribution
SAGARPA	Mexican Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación de Mexico)
SDG	Sustainable Development Goals
SDMX	Statistical Data and Metadata eXchange
SE	Mexican Secretariat of the Economy (Secretaría de Economía de Mexico)
SHCP	Mexican Secretariat of Finance and Public Credit (Secretaría de Hacienda y Crédito Público de Mexico)
SNA	System of National Accounts
SSR	Self-Sufficiency Ratio
SUA	Supply Utilization Account
TWG	Technical Working Group
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNPD	United Nations Population Division
UNSD	United Nations Statistics Division
UNWTO	United Nations World Tourism Organization
USDA	United States Department of Agriculture
WASDE	World Agricultural Supply and Demand Estimates
WCO	World Customs Organization
WTO	World Trade Organization
WFP	World Food Programme

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It is important to note that these Guidelines suggest imputation approaches and data sources for country-level compilers, such that the strategies outlined here are not identical to those implemented indiscriminately for all countries in the FAO-compiled FBS.

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Preface

These Guidelines were developed under the Global Strategy to Improve Agricultural and Rural Statistics framework, using the expertise of various staff members within the Statistics Division of the Food and Agriculture Organization of the United Nations (FAO). These Guidelines on Food Balance Sheet (FBS) compilation transverse the three foundational pillars of the Global Strategy (produce a minimum set of core data, better integrate agriculture into the National Statistical Systems, and improve governance and statistical capacity building), as they seek to advise countries on identifying potential core data sources (and alternatively on imputing missing data), ensure that data from disparate sources are coherent by analyzing them in a unified framework, and suggest mechanisms through which data quality processes and transparency can be improved.

The methodologies and approaches described in these Guidelines represent the latest innovations in both the imputation of missing data and the balancing of food commodity accounts. At the same time, these methods continue to be improved and refined, striving to reach the goal of producing consistent, replicable food balance sheets for all countries of the world, even in the face of limited source data. As further innovations are introduced, it is the hope that these Guidelines will be updated to reflect the most up-to-date advice for country-level FBS compilers.

Even as these innovations in imputations and balancing are introduced in these Guidelines, there is also a recognition that these new approaches may not be appropriate for or easily adopted by all countries. For this reason, these Guidelines have also striven to propose alternative approaches that, although they may deviate from the proposed "gold standard", may be more realistic, applicable, and sustainable in the context of developing countries.

Because FBS cover so many products, industries, and processes (not to mention the potential idiosyncrasies between countries), they can become extremely detailed and complicated. These Guidelines, however, strive to outline the process of FBS compilation by balancing comprehensiveness with manageability. As such, several topics relevant to FBS compilation are not covered here, or are only covered in very basic detail. Most prominently, these Guidelines cover only data sources and imputation procedures for crop and livestock products—no guidance on fishery or forestry data sources or imputation procedures is mentioned. However, recognizing that fishery and forestry products are important contributors to healthy diets, country-level FBS compilers should strive to include these commodities in their comprehensive FBS, if possible. These sectors may also be covered in future versions of these Guidelines.

In addition, these Guidelines provide suggestions only for the compilation of national-level FBS. Although there is a growing desire for the compilation of regional or subnational FBS accounts (with the goal of better targeting food security policies within countries that have wide regional disparities), these kinds of balance sheets require additional approaches, tools, and data sources not covered in these Guidelines. That being said, many of the other data source and imputation approaches suggested here could easily be adapted and applied to a regional context, should the user country so desire to utilize this tool as a starting point.

Lastly, it should be emphasized that while these Guidelines cover the concepts and processes necessary to derive national-level FBS estimations, compilers often also seek the best tools available to help them implement these processes. At this writing, no such comprehensive tool is available to offer as accompaniment to these Guidelines. This is partly due to a belief that compilers who have a solid understanding of the underlying processes and calculations are better able to think critically about all of the moving parts of the FBS, such that they can better identify potential sources of problems and, in turn, propose solutions. At the same time, it is envisioned that additional tools (including software, e-learning courses, and guidance on analyzing FBS outputs) will be developed and made available in a comprehensive FBS toolkit in future.

1

Introduction

1.1 Overview

There is a global recognition that statistically sound, reliable data on food and agriculture is needed to understand the current situation of agriculture and food supplies within any given country, track progress against established development goals, and inform future evidence-based policy decisions. Through the Global Strategy to Improve Agricultural and Rural Statistics (also known solely as "The Global Strategy"), efforts have been made to develop and promote the most cost-effective means by which countries can collect data on various aspects of food supply and utilization, with the end goal of providing a better foundation for policy evidence-based decision-making. Particularly in the context of the Sustainable Development Goals (SDGs), the value of reliable, globally comparable agricultural data to measure progress against certain targets is being realized.

While data on agricultural production, imports, exports, or stocks can be valuable on their own, in isolation, none of these elements can accurately describe the complete food circumstances of a country. For example, if production of a given commodity falls, in the absence of other information, one could deduce that availability of that good would fall as well. But in an instance where imports were rising more than production was falling, an increase in availability could be expected. This simple illustration serves to underscore the idea that only when all of these elements are combined into a holistic framework can meaningful conclusions be drawn regarding a country's food situation. Food balance sheets are just such a framework, joining together all aspects of a nation's food supply and demand in a manner that allows for the validation of the underlying estimates while also providing the context necessary to allow for a complete analysis of the individual elements.

The goal of these Guidelines is to provide countries with the methodological framework and tools to compile high-quality food balance sheets (FBS) for crop and livestock products.[1] To that end, these Guidelines are organized in the following manner:

- **Chapter 1** serves as an introduction to the topic, defining FBS and providing information on ways in which they can be useful to countries.

[1] Compilers will note that consumers also derive calories from fishery products. Although fishery products are not covered in these Guidelines, the same general guidance would apply in constructing fishery product balance sheets—all elements of supply and utilization must be accounted for, and calories are derived from quantities of food. However, specific issues related to imputation and estimation of fish catch, loss, and trade are not covered here.

- **Chapter 2** presents an overview of the methodological principles that underlie the construction of country-level FBS, including a discussion of the basic supply = utilization identity, an introduction to Supply Utilization Accounts and commodity trees, and a brief description of the recommended balancing mechanism.

- **Chapter 3** builds on the concepts introduced in Chapter 2 by focusing on the data needed to compile FBS. The chapter includes a discussion of the necessity of organizing work within a Technical Working Group that will define the scope of the task, before proceeding with information on how data should be assessed and considered before FBS compilation. This is followed by detailed discussions of suggested data sources and imputation approaches for each of the variables included in the FBS.

- **Chapter 4** brings together all of the components discussed in Chapter 3 into the complete FBS framework by walking readers through a step-by-step guide to FBS construction.

- **Chapter 5** concludes by offering some final considerations on data quality, advice on data dissemination, and guidance on FBS interpretation.

1.2 What is a Food Balance Sheet?

A food balance sheet (FBS) can be defined as an aggregated and analytical dataset that "presents a comprehensive picture of the pattern of a country's food supply during a specified reference period."[2] This is achieved in an accounting framework, wherein all potential sources of both supply and utilization of a given food product are specified. The quantities allocated to all the sources of total supply—amount of the food item produced, the amount of the food item that is imported, and the amount of the item that is either added to or taken from stocks—must be equal to the quantities allocated to all the sources of utilization, which can include exports, losses along the supply chain[3], livestock feed, seed use, tourist food, food processing, industrial uses, other uses, and food available for consumption by a country's residents. This balance is compiled for every food item (estimated on a primary commodity equivalent basis) consumed within a country, and then all of the primary commodity equivalent balances are combined into one overall food balance sheet. An estimate of per capita supply for each food item—both in terms of quantity and, through the application of food conversion factors, in terms of caloric value, protein, and fat content—can then be derived by dividing by the country's population. These per capita estimates of caloric value for individual food products are then summed to arrive at the total daily per capita dietary energy supply (DES) of a country.

Viewing the domestic food supply and demand situation within this framework allows countries to examine conditions in a holistic way, both aiding food supply analysis and facilitating food policy

[2] For this definition and a more extended description of the motivation behind the development of food balance sheets, see the 2001 FAO food balance sheets handbook: "Food Balance Sheets: A Handbook," http://www.fao.org/docrep/003/X9892E/X9892E00.HTM.

[3] Throughout these Guidelines, the term "supply chain" is defined as in van der Vorst et al. (2007): "a sequence of processes and flows that aim to meet final customer requirements, and that take place within and between different stages along a continuum, from production to final consumption." This term is often conceptually used interchangeably with "value chain," but we refer in these Guidelines only to the supply chain.

formulation. Food balance sheets have a wide range of applications however, with some of the most common uses detailed in the following section.

1.3 Potential uses of FBS

An increasing number of countries are compiling comprehensive food balance sheets, despite the fact that the exercise can be time-consuming and require additional resources for agricultural statistics and analysis. The rising interest in compiling FBS likely has to do with both the value of the data generated through this process, and the myriad of applications of that data. For countries currently considering whether or not FBS can be a positive addition to their country's statistical system on food and agriculture, some possible applications are outlined here.

Measuring and analyzing overall food supply

Perhaps the most widely-utilized application of FBS is as a mechanism to estimate a country's overall DES and macronutrient availability (fats and proteins, in addition to kilocalories). Because FBS track overall food *availability* and not actual consumption, DES cannot be used as an estimate of how much nourishment the average resident is consuming, but rather as an indicator on whether or not sufficient food is available nationally—particularly for developing countries, where undernourishment is more likely to be a problem. At the same time, in some developed countries, food availability has been used as a proxy for actual food consumption.[4]

Along with providing a measure as to whether or not sufficient food is available, FBS are also useful for analyzing the overall content of a country's diet, including determining if there is sufficient availability of a certain variety of food. As an example, estimates derived from FBS were recently used to analyze declining fruit and vegetable consumption in the United States (Lin and Mentzer Morrison, 2016).[5] In a developing country context, analyzing shortfalls in availability of certain foods in the FBS could be one approach to better understanding the nature of malnutrition in a given nation.

The framework is also flexible enough that it could be extended to analyze the availability of additional vitamins and minerals, contingent only upon the utilization of sufficiently detailed nutrient conversion tables.

It should be noted here, however, that nutrient content (of both macro and micronutrients) may vary widely within commodity categories, depending upon which variety or type of commodity dominates in domestic food supplies. For this reason, in order to ensure the most accurate estimates possible, compilers are encouraged to utilize their most recent country-specific nutrient conversation tables

[4] Documentation for USDA's "Food Availability Data System" specifically notes, "The food availability data series is a popular proxy for actual food consumption and is especially useful for those interested in time series data." For more information, see https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-documentation/.

[5] This study used loss-adjusted supplies of fruits and vegetables, derived from food availability data estimated through a supply and utilization framework.

(additional information on nutrient conversion tables—including links and references to some commonly-used international tables—is elaborated in section 3.5.12).

Food supply assessment through the calculation of indicators

One of the primary applications of FBS is the calculation of derived indicators using FBS data. These indicators can be used to analyze a wide range of concepts, including hunger, malnutrition, import dependence, and food self-sufficiency. One of the most widely-known of these indicators is the Prevalence of Undernourishment (PoU), which measures the "probability that a randomly selected individual from a population is found to be consuming less than her/his requirement for an active and healthy life."[6] This indicator is calculated by estimating a distribution of food consumption within a country during a given reference period, where food availability (as measured by the DES) is a proxy for the mean level of consumption in that distribution.

Other well-known indicators derived from FBS data include the Self-Sufficiency Ratio (SSR), which compares the magnitude of a country's agricultural production to its domestic utilization, and the Import Dependency Ratio (IDR), which compares the magnitude of a country's imports to its domestic utilization.[7]

Although these are only a few examples, because of the wealth of data contained within the FBS framework, it can be used to derive countless indices and indicators depending upon the variables of interest to the end user. As one example, SDG 12.3 tasks countries with reducing food loss. Because loss appears as a variable in the food balance sheet, those quantities could be useful in calculating an indicator on food loss.

Benchmarking and market analysis

To the extent that the methodology for compiling FBS and deriving DES estimates is similar across countries, it is possible to use these estimates to compare food availability from one country to another. This comparison is possible both on an aggregate level and on a product-specific level. For example, users can choose to compare the per capita food availability of almonds between nations. These types of comparisons can have various applications. First, analyzing comparative diets can be a useful exercise in the area of nutrition policy. As one example, say that Country A determines that domestic per capita availability of fruit and vegetables is too low. Policymakers in Country A can then consult contemporaneous food balance sheets from other countries to identify places with relatively higher food availability of fruits and vegetables, and then research more deeply the policy frameworks within those other nations to determine if there are any relevant policies in Country B or C that could lead to higher fruit and vegetable availability in Country A.

Another application of food balance sheets in the context of comparative food availability is the potential for market research. For instance, say that Country B is a small exporter of pistachios. Firms

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[6] For more information on the methodology underlying the calculation of the PoU, see FAO's Food security methodology webpage, at http://www.fao.org/economic/ess/ess-fs/fs-methods/fs-methods1/en/.
[7] For more details on the methodology underlying the calculation of both the SSR and the IDR, see, for example, FAO's 2012 Statistical Yearbook, available at: http://www.fao.org/docrep/015/i2490e/i2490e00.htm.

or export promotion agencies within Country B could then use food balance sheets to identify countries with either high comparative food availability of pistachios as potential export markets with existing consumer demand, *or* identify countries with comparatively low food availability of pistachios as possibilities for future market development.

Comparing food availability across time

Just as an FBS compiled for one year will provide a snapshot of a country's food supply, compiling FBS over a period of years will allow users to track changes in the food supply over time, including estimated total caloric availability, growth of consumption in new products, and general changes in dietary composition. Such time series datasets are extremely useful to both academics and policymakers. For example, rising obesity rates within a country could be correlated back to rising overall per capita food availability estimates from the FBS. Governments can then use this information to support certain policy measures to stem the growth in obesity.

FBS time series data on per capita food availability can also be valuable to forecasting future consumption trends. This application could be useful both for policymakers and for firms seeking new market opportunities.

Improving national statistical integration

Food balance sheets by their nature provide a framework for reconciling data, as total supply must equal total utilization. This can be a challenging exercise, as for most countries and most products, the necessary input data will come from a variety of different sources and agencies within one government, and even potentially from semi-official actors providing information on a single commodity. While reconciling these data may be time-consuming, the process provides a unique opportunity to both harmonize data collection efforts across agencies (ensuring that bodies are measuring or estimating quantities in apples-to-apples comparisons) *and* validate estimates by placing them in the context of the commodity's overall supply and demand picture. By bringing together all of the relevant stakeholders at this stage, problems or inconsistencies in data collection and estimation can be identified early, and a country's overall agricultural statistical program can be improved.

Two examples of this improved national statistical integration can be highlighted. The first is the usage of so-called Interagency Commodity Estimates Committees (ICECs) at the United States Department of Agriculture (USDA) in their formulation of supply and demand balances for the monthly World Agricultural Supply and Demand Estimates (WASDE) report. These committees are composed of representatives of various agencies within USDA, and the data used by the committees to formulate the commodity balances come from a variety of additional sources (including the National Agricultural Statistics Service and the Census Bureau).[8]

[8] For more information on the methodology of compiling the commodity balances used in the WASDE using various sources, see the following webpage from USDA's Office of the Chief Economist (OCE): http://www.usda.gov/oce/commodity/wasde/prepared.htm.

A similar system has recently been established in Mexico called the Dashboard for Strategic Agrifood Products (Tablero de Control de Productos Estratégicos Agroalimentarios). Under this system, a working group meets periodically to compile supply/demand balances for strategic agricultural products. This working group composes various commodity balances using information from the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), the Secretariat of the Economy (SE), and the Customs General Administration (AGA) housed within the Secretariat of Finance and Public Credit (SHCP).[9]

While both of these examples refer to statistical integration in the context of deriving commodity balances, at least the USDA example, the data on "food" derived through the commodity balance estimation process is then in some cases used to estimate per capita availability of the relevant food commodities.[10]

It should be noted that the Global Strategy already recommends that countries set up a permanent steering committee on agricultural statistics and a technical working committee on agricultural statistics in the context of their individualized Strategic Planning for Agriculture and Rural Statistics (SPARS) plans, specifically for the purpose of bringing together all relevant actors in the agricultural statistics space (Global Strategy, 2014). The technical working committee in particular could be utilized as a vehicle for improved national statistical integration in this context, as it aims to bring together both strategic stakeholders and representatives of sub-sectors, who could then participate in a collective food balance sheet validation exercise.

Inputs in national accounts

At their heart, FBS are an accounting framework specific to food and agricultural products. In fact, the FBS framework is very similar to the System of National Accounts (SNA) supply-use framework.[11] As such, they are naturally complementary to the estimation of national accounts. National accounts typically include estimations of household and collective consumption, trade in goods and services, and output and value-added by industry. Improved measurement or estimation of agricultural production and utilization—validated in conjunction with import and export data, as well as other components of supply and demand—will lead to improved national account estimates as well. In turn, since national accounts data are used for all manners of economic and policy analysis, improved data in this area could lead to more targeted—and more effective—policies.

[9] Although SAGARPA and SE are the primary governmental bodies compiling the balances—as stated on Mexico's Agrifood and Fisheries Information Service (known by its Spanish acronym SIAP) website for "Cosechando Números del Campo," available at: http://www.numerosdelcampo.sagarpa.gob.mx/publicnew/—the individual commodity balances also cite AGA as an additional source of information (see, for example, the sorghum balance, available at: http://www.numerosdelcampo.sagarpa.gob.mx/publicnew/productosAgricolas/cargarPagina/5).

[10] The balances for food grains are the best examples. For more information on this point, see the food availability documentation on grains, available at: https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-documentation/#grains.

[11] For more information on national accounts, see UNSD's SNA website, available at: http://unstats.un.org/unsd/nationalaccount/sna.asp.

It is worth noting here also that just as FBS can be an input into National Accounts, National Accounts can also provide helpful data for the compilation of FBS.

Inputs in economic models

Because FBS are accounting frameworks, FBS data can be used by many models that are structured using the supply-use format of national accounts data described above. Most partial equilibrium models for agriculture utilize commodity balances in their data structures—the OECD-FAO AGLINK-COSIMO model and the IFPRI IMPACT model are two of the main models used at the international level, but country-specific models also exist. One example is the EU AGMEMOD (Agricultural Member States Modeling) partial equilibrium model, which has been expanded to include Ukraine and Turkey in order to inform analyses on how developments inside either of these countries might affect global markets.[12] These inputs from FBS can then serve as base year data sources, permitting either simulation analysis or facilitating projection into the future. While FBS data may be the primary data source for many of these models, the final input dataset will likely not be identical to the data in the FBS, as many of these types of models impose a zero net trade rule as their solving algorithms. Nonetheless, because these models are widely used for agricultural projections and policy analysis (both by academics and governments alike), improved food balance sheet estimates can improve the overall quality of a country's agricultural sector modelling capabilities.

1.4 Caution in interpreting FBS estimates

As noted previously, FBS provide a framework from which to understand general trends in changing food consumption patterns by measuring average food availability. But while FBS can be useful tools for assessing the food situation of a country, users must also be aware of their limitations in order to accurately interpret FBS estimates.

Food availability, not food consumption

Perhaps the most important caveat of analyzing food balance sheets is related to the meaning of the per capita dietary energy supply estimates. It should be emphasized here that these are *available* dietary energy supplies, and can thus be described as *apparent food consumption*[13]—that is, FBS estimates represent food that is intended for human consumption available for purchase by consumers at the point of sale. This concept is distinct from *effective food consumption*, which is the actual quantity of food consumed. In practice, this means that FBS food use estimates are not net of food waste at the retail or household levels. Particularly in developed countries, food waste at the household level can be substantial[14], such that the DES is likely to overestimate the amount of food

[12] For more information, see van Leeuwen et al. (2012) and van Leeuwen et al. (2011).
[13] This term "apparent food consumption" is used here so as not to be confused with the term "apparent consumption", which is commonly used in the literature as a measure to indicate supplies available for all uses, calculated as production plus imports minus exports (and sometimes adjusted for stock changes). See, for example, UNSD (2016).
[14] Two studies detailing the scale of developed country food waste include Buzby et al. (2014) and FUSIONS (2016). Buzby et al. (2014) estimated that consumer-level losses were equivalent to 21 percent of total U.S. food supplies in 2010, while FUSIONS (2016) estimated that roughly 11 percent of the food produced in the EU in 2011 was wasted by households (an estimated 92 kilograms per capita were wasted at the household level in the EU, out of 865 kg of food produced per person).

actually consumed. This is less of a problem in developing countries, where food waste at the household level is limited compared to food loss at other stages of the supply chain.

No accounting for distributional differences

Estimates derived through an FBS framework represent only an overall average quantity within a country of either food or nutrient availability. While useful for certain types of analysis, these average estimates may mask other underlying trends in consumption amongst disparate groups of people within the same country. This is particularly the case with the most food-insecure segment of the population. In many developing countries, for example, consumption patterns may more accurately be described using bi-modal distributions: that is, one portion of the population will consume a certain food at an average value of a certain level, and another portion of the population will consume that same food at a higher average level. The resulting overall country-wide average would reflect neither group's consumption levels. Particularly when analyzing FBS for countries with very unequal income distributions, it is important to keep these types of distributional limitations of the FBS in mind.

Compatibility with household surveys

While household surveys are another useful tool in analyzing consumption habits of individuals and households, users are advised that food availability estimates derived from FBS can be expected to differ from those indicated in household surveys. This discrepancy has several sources. The first comes from the fact that FBS estimate food availability, while household surveys are more likely to measure actual food consumption levels. A second source of discrepancy is that FBS take into account food availability at *all* locations within a country (including schools, hospitals, military, prisons, restaurants, food service)—not merely household food availability.[15] A third source of discrepancy may be survey coverage and representativeness: household surveys may only reflect consumption patterns for a given region or income group, and thus may not be statistically representative of consumption patterns in the society as a whole. A fourth source of potential discrepancy could be the number of commodities and the aggregation level considered in the household survey—household surveys may record consumption of specific derived goods, whereas FBS may have little information on those derived goods and instead report availability for a less processed version (such as a household survey reporting consumption of tortillas, while in the FBS, food availability may instead be recorded for the flour used to make that tortilla). The last source of discrepancy may be timing. FBS account for food availability over a full year, while household surveys are much more likely to capture a smaller period of time. Particularly for countries that experience a lean season, household survey results can vary widely depending upon when the survey takes place.

Nevertheless, the general trends and overall dietary patterns represented in the two should, in most cases, be the same. In addition, household surveys theoretically can serve as either a key source of data for food estimates within FBS or as a validation tool for FBS accuracy, provided that the underlying differences in the two sources of data are well understood. At least one scholarly attempt

[15] It should be noted here that the preceding two factors make it more likely that food supplies estimated from an FBS framework will be higher than those obtained from household surveys.

has been made to understand and reconcile these two data sources, and countries may find that exercise useful when comparing their own data.[16]

Country-level FBS compilers should note that FBS and household surveys should be treated as complementary tools and not substitutes for the following reason—household surveys are costly and lengthy endeavors, such that most countries can only afford to run such surveys once every four or five years. This leaves researchers and policymakers without any data in the interim to inform analysis. By comparison, FBS can be compiled each year at a much lower cost, generating an annual dataset that can be used by various actors for research and analysis.

Commodity Balances and FBS

As described above, FBS can be considered as one type of accounting framework from which the overall supply and demand situation of a particular commodity can be analyzed. For this reason, FBS can be said to belong to the general family of commodity balances (indeed, the process of deriving FBS begins with the compilation of a commodity balance). However, there are a couple of differences that should be noted. The most obvious of these differences is that FBS are composed for only food-related commodities. For example, although a country may wish to publish a commodity balance for natural rubber, this balance would not be considered as a food balance sheet because there is no food element to rubber. The second difference has to do with the assigning of nutrient value to the "food" element in a commodity balance. Although any given country may publish a commodity balance for a product that is consumed as food, this balance is not considered to be a "food balance sheet" until the quantity estimates of food have been reported in their nutritive equivalent. The final difference is a more technical one that has to do with the mechanics of composing food balance sheets, in that food balance sheets should contain aggregated estimates of both a primary commodity *and* all of its derived products, expressed at the primary commodity equivalent level. While many countries produce commodity balances for primary products, they often do not account for goods derived from those primary products, and thus may underestimate total availability and consumption for groups of certain commodities. Countries may wish to publish separate accounts for primary and derived commodities rather than aggregating them, but aggregated primary equivalent accounts are preferred for purposes of comparability across countries.

1.5 Fundamental principles of FBS construction

While the general overall approach of constructing FBS will be outlined in these Guidelines, the exact process followed will differ from country to country, depending upon data availability, food supply chain structure, expertise, and other potential resource constraints. Nevertheless, compilers should adhere to certain basic principles in order to ensure that their country-level FBS are reproducible, coherent, and transparent. These principles, discussed in further detail below, are:

- Measurement first

[16] For further information, see Grünberger (2014).

- Document data and processes
- Feedback and collaboration

Country-level compilers are encouraged to consider these fundamentals when drafting their country's overall FBS construction plan, and keep these always in mind when updating or improving their processes.

Measurement first

Without question, the key to producing FBS that provide consistent, reliable estimates that are most effective at aiding analysis and policymaking is accurate measurement and availability of key input data on all supply and use variables. While countries can in theory produce FBS with only certain data inputs, estimates of food availability derived from sparsely-populated input data frameworks will themselves potentially be accompanied with large margins of error, which limits their usefulness as an analytical tool. At the same time, most imputation modules for missing data rely on some measurement of data having taken place in the past, such that it may not be possible to impute missing data without the use of some underlying source data. For these two main reasons, it is recommended that countries *first* invest resources in improving measurement of input data before attempting to compile country-level FBS. This point bears repeating: there is no substitute for input data measurement, and reliable FBS depend upon reliable input data.

Document data and processes

These Guidelines outline the general process of FBS compilation, but data sources and approaches will vary from country to country, and may even change within a country over time as new data sources become available and new imputation approaches are developed. Staff turnover is also a common occurrence in the agencies charged with developing FBS. For all of these reasons, it is essential that compilers document data sources, applied methodologies, and solutions to identified data inconsistencies on a real-time basis. This should include the drafting of accompanying metadata—that is, data that describes or gives other background information about the dataset. Such documentation is essential both for continuity's sake (to ensure that new compilers are able to produce estimates in a manner consistent with the previous data series), *and* to ensure that future users can understand the rationale behind the development of certain estimates or the choice of one methodology over another.

Feedback and collaboration

FBS should not be compiled in a vacuum. Instead, the process should be a collaborative one that involves all relevant actors within the supply chain, and, to the extent possible, users of the resulting datasets. Ideally, all relevant actors should collaborate within a permanent Technical Working Group (TWG) (at the very least, the final output should be validated by a TWG). This validation by multiple actors is important, because experts in certain supply chains will likely have additional knowledge on product specifics that will contribute to the production of more accurate balance sheets. This practice of validation by multiple actors can also lead to improvement of input data…if actors are aware that the accuracy of balance sheet estimates are limited by the quality of the input data, then they may be more likely to participate in efforts to improve said input data.

This process of feedback also serves to build confidence in the estimates produced through the FBS framework: if the sources of data are explained and understood, then users feel more comfortable using those estimates for their own data needs.

1.6 Summary

This chapter has attempted to introduce the overall concept of food balance sheets to the lay user or novice compiler. The overall framework was introduced, some potential uses of FBS were noted, and some notes of caution on FBS interpretation were described. The chapter closed by highlighting the fundamental principles of FBS construction: measurement first, document data and processes, and feedback and collaboration. The following chapter will focus on the preparatory steps leading up to the construction of country-level FBS.

2

Methodological principles for the construction of country-level FBS

2.1 Overview

The process of constructing food balance sheets at the country level should not be undertaken without a thorough understanding of the mechanics of the FBS by all compilers. This chapter will introduce all of the relevant concepts involved in compiling a food balance sheet, including an explanation of the basic underlying identity, a description of all supply and use variables, a description of additional necessary variables, an explanation of the difference between supply utilization accounts (SUA) and food balance sheets, an explanation of how commodity trees link SUAs back to the primary commodity equivalent-level FBS, and a discussion of the balancing mechanism.

2.2 The basic identity and approach

Food balance sheets are built on the basic premise that within a given country in a given year, the sum of all aspects in the supply of a given food product must be equal to the sum of utilizations for that product. This concept is commonly expressed in two different basic identities: total domestic supply is equal to total domestic utilization, or total supply is equal to total utilization (equations (2-1) and (2-2)).

Domestic supply = domestic utilization:

$$\begin{aligned} &\mathit{Opening\ Stocks} + \mathit{Production} + \mathit{Imports} - \mathit{Exports} \\ &\quad = \mathit{Food} + \mathit{Feed} + \mathit{Seed} + \mathit{Tourist\ Food} + \mathit{Industrial\ Use} \\ &\quad + \mathit{Loss} + \mathit{Residual\ Use} + \mathit{Closing\ Stocks} \end{aligned} \tag{2-1}$$

Total supply = total utilization:

$$\begin{aligned} &\mathit{Opening\ Stocks} + \mathit{Production} + \mathit{Imports} \\ &\quad = \mathit{Exports} + \mathit{Food} + \mathit{Feed} + \mathit{Seed} + \mathit{Tourist\ Food} \\ &\quad + \mathit{Industrial\ Use} + \mathit{Loss} + \mathit{Residual\ Use} + \mathit{Closing\ Stocks} \end{aligned} \tag{2-2}$$

More exact definitions of these variables follows below in section 2.2.1.

The only difference between the two equations is the placement of exports. In equation (2-1), supply is defined in terms of net trade (imports minus exports). In equation (2-2), imports are registered as a supply variable, while exports are recorded as a utilization variable.[17] Countries are free to choose the conceptualization that makes the most sense for their own FBS.

At the same time (as will be described in subsequent sections), many countries do not collect data on stock levels for the majority of products. For this reason, the supply=utilization identity is often expressed instead using some estimate of the change in stock levels during the reference period (i.e., either a stock buildup or a stock drawdown) rather than including estimates of absolute opening and closing stock levels. In the contexts of equations (2-1) and (2-2), this can be expressed as:

Domestic supply = domestic utilization:

$$\begin{aligned} &Production + Imports - \Delta Stocks \\ &\quad = Food + Feed + Seed + Tourist\ Food + Industrial\ Use \\ &\quad + Loss + Residual\ Use \end{aligned} \tag{2-3}$$

Total supply = total utilization:

$$\begin{aligned} &Production + Imports - \Delta Stocks \\ &\quad = Exports + Food + Feed + Seed + Tourist\ Food \\ &\quad + Industrial\ Use + Loss + Residual\ Use \end{aligned} \tag{2-4}$$

where *ΔStocks* is defined as $\Delta Stocks = Closing\ Stocks - Opening\ Stocks$.

The basic identity can also be specified with an additional utilization variable—*Food Processing*—as below in equation (2-5):

Alternative specification of total supply = total utilization, with food processing included:

$$\begin{aligned} &Production + Imports - \Delta Stocks \\ &\quad = Exports + Food + Food\ Processing + Feed + Seed \\ &\quad + Tourist\ Food + Industrial\ Use + Loss + Residual\ Use \end{aligned} \tag{2-5}$$

[17] It should be noted that countries where stock levels are either measured or estimated sometimes include "beginning stocks" as a supply variable and "ending stocks" as a utilization variable, thus effectively eliminating *ΔStocks* from the equation. However, for the purposes of these Guidelines, the specifications here are preferred because the imputation of *ΔStocks* is a much simpler process with stronger theoretical underpinnings. More details on the imputation of stock level changes can be found in section 3.5.3.33.5.3.3.

The reason food processing is not always included in expressions of the basic underlying identity is that this variable is typically dropped in the final stages of FBS compilation (standardization and aggregation) in order to avoid double-counting (the rationale on why this is so is explained in the guide to FBS construction laid out in Chapter 4). However, food processing should be included as a utilization variable in the specification of the preliminary individual commodity balances (covered below in section 2.3), so it may be helpful to conceptualize the basic identity in this manner.

Ideally, countries should measure each of these variables for each product, with the measurement including both an expected value of the estimate *and* some quantification of the confidence of said estimate—deemed here as a "tolerance interval" (for values that are measured, this estimate of confidence is the measurement error). The rationale behind the provision of both the expected value and the tolerance interval will be further explored in section 2.4, but for now, it suffices to say that both components will be key to balancing the overall identity.

2.2.1 Supply and use variables

The variables elaborated in the basic supply = utilization identity should, for the most part, be intuitive concepts to FBS compilers. However, a more exact definition of these concepts is warranted here to ensure that the scope of what is and is not included in the calculations is clear. Countries should try to adhere to these definitions where possible in order to ensure that calculations of dietary energy supply derived from country-level FBS are a faithful approximation of the real food supply situation. For example, reporting of only commercial production would lead to the underestimation of the supply of some products in countries where the product is commonly grown in household gardens or, more generally, for own consumption, which in turn would cause an underestimation of total per capita availability. All definitions here are adapted from the FAOSTAT Food Balance Sheets Glossary[18] and the FBS Resource Book (Schmidhuber 2016).

Production

Data for *production* in the food balance sheet should include all production quantities of a given commodity within the country in question, including both commercial and non-commercial production (such as from home gardens or subsistence agriculture). Production of primary products should be reported at the farmgate level, such that it does not include harvest loss. It should include, in theory, any post-harvest on-farm loss occurring during the different farm operations, such as threshing, cleaning/winnowing or storage. Data for meat production should include both commercial and farm slaughter, and production should be expressed in terms of carcass weight. Production of any derived or processed commodities refers to the total output of the product after transformation. This transformation may occur either at the household or at a commercial establishment. It should be noted here that the standard unit for the reporting of agricultural production at the international level is metric tonnes (MT), but many countries also use local units. Compilers should also note that for

[18] The glossary is available by accessing the metadata for the FAO food balance sheets published on FAOSTAT at http://www.fao.org/faostat/en/#data/FBS.

production that straddles calendar years, production should be assigned to the year in which most of the crop will be consumed (more details on this concept can be found in section 3.4.1.3).

Imports and Exports

Imports and *Exports* are the two primary types of foreign trade, which can be defined as the exchange of goods (and services) across international borders. More precisely, *imports* are transboundary flows of goods destined for a given final destination country that add to the total supply of goods available in that country, while *exports* are transboundary flows of goods from a given country of origin that take away from the total availability of goods in that country. Goods that come in and exit a given country without having undergone any type of transformation are categorized separately as re-exports. In the context of the food balance sheets, re-exports should be added to exports to fully account for all outgoing trade flows. This is particularly important for countries that act as transportation hubs…importing goods from one destination, then packing them onto a different vessel to ship elsewhere. If re-exports are not counted in these instances, then the food balance sheet would describe a distorted picture of the food situation—one where all goods imported remain part of domestic supplies and are subsequently consumed.

It should be noted here that, to the extent possible, imports and export estimates should endeavor to cover both official and unofficial trade flows, including food aid shipments. For certain countries and commodities, unrecorded trade flows may be substantial, potentially having a large knock-on effect on food availability estimates.

Stocks

Stocks are defined as the aggregate total of product allocated to storage for use at some future point in time (regardless of their intended future utilization). Stocks can be held by a variety of actors (governments, manufacturers, importers, exporters, wholesale merchants, farmers) at any level of the supply chain—from production up to, but excluding, retail.[19] As noted above, stocks can be accounted for in one of two ways in the balance sheet setting. First of all, stock levels at both the beginning and end of the period can be noted (on the left and right-hand side of the equation, respectively). Alternatively, the FBS framework can be elaborated by estimating the change in stocks from one time period to the next as a component of supply. That is, if closing stocks are smaller than opening stocks, that implies that stock withdrawals were made during the period, thus increasing supplies.

Food availability

Food availability is defined as the quantity of any substance, whether raw, processed or semi-processed (including drinks) that is available for human consumption during a given reference period. As referred to in the foregoing discussion on what quantities reported in food balance sheets represent, quantities defined in this variable represent the amount of food that is available for consumption at the retail level. For this reason, any waste (and/or loss) that occurs at the retail or consumer levels is included in this quantity, since that food was technically available for human consumption. It is

[19] Because food availability is defined at the retail level, there is no need to account for retail level stocks.

important to note that because the quantities reported under this variable represent those available for food, they will typically be higher than quantities reported through household-level consumption surveys. Additionally, quantities reported here represent food available for consumption not only in households, but also in restaurants and institutions (hospitals, schools, military bases, prisons, etc.). Lastly, as these quantities should represent how the product is sold, these quantities are expressed in gross weight, such that they may include non-edible parts. As such, when these quantities are converted into nutrients, either some conversion factor should be applied that calculates edible quantities before conversion into nutrients occurs, *or* the nutrient conversion factors should take into account the fact that the quantities are in gross weight and not net of non-edible parts.

Food processing

Food processing refers to quantities of a food product that are directed toward a manufacturing process and are then transformed into a different edible commodity with a separate entry in the food balance sheet. These separate commodities might be structured within the same commodity tree or food group (e.g., tomatoes that are processed into tomato paste), or they could be completely separate (e.g. barley is processed into beer, which typically is aggregated into an alcoholic beverages category and not into the barley balance). For derived commodities in the same food group, the food processing variable should disappear in the final stages of FBS compilation to avoid double-counting. For quantities that were used in the production of derived commodities in different groups, the food processing variable should remain in the final account.

It should be noted here that quantities devoted to the manufacture of non-edible products (such as soap or biofuels) should be accounted for under *industrial use* and not *food processing*.

Feed

Feed is defined as all quantities of commodities—both domestically produced and imported—that are available for feeding to livestock and poultry. Many commodities that are used as feed are byproducts of industrial processes, such as oilcake, dregs, or distiller's dried grains with solubles (DDGS). While they are included in initial calculations most will not be aggregated up to the primary commodity level in order to avoid double counting.

Seed

Seed is defined as any quantity of a commodity set aside for reproductive purposes in the following year. This can include seed for sowing, plants for transplanting, eggs for hatching, and fish used as bait. This quantity should also take into account double or successive sowing.

Tourist food

Tourist food refers to food that is available for consumption by non-resident visitors to a given country during the course of their stay. While the term "tourist" is used here, it is worth emphasizing that this variable covers food availability for *all* non-residents, including tourists, business travelers, or non-resident migrants in instances where they are not counted in the country's population. This variable is expressed in net terms in the food balance sheets (as in, food available for consumption by incoming visitors minus food that would have been consumed by residents who have traveled to other countries).

It is worth noting that countries with negligible numbers of visitors may choose not to estimate tourist food as a separate FBS component. Instead, tourist food can be captured in other residual uses. However, for certain countries—particularly small island states—accounting for tourist food is essential to accurately estimating local consumption patterns.

Industrial use

Industrial use is defined as any quantity of a given product used in some non-food transformation or manufacturing process, including for biofuels, cosmetics, detergents, or paints.

Loss

In the context of the FBS, *loss* refers to quantities of a product that leave the supply chain and are not diverted to other uses. They result from an involuntary activity and can occur at any node of the supply chain after the harvest and up to (but excluding) the retail/consumption stage. This variable can also be referred to as *post-harvest* or *post-slaughter* loss. This category does not include any quantities of food wasted or lost at the consumer or retail level. Additionally, for consistency with other variables in the food balance sheets, quantities reported here should include both edible and non-edible parts. It is also important to note here that any volume of product lost in the transformation of primary products into processed products is accounted for through extraction rates and conversion factors, and for this reason is excluded from loss. However, loss that occurs in all other utilizations (particularly during storage and transportation) is included.

Residual and other uses

Residual and other uses can, in most cases, be defined as the combined imbalance and accumulated error in the supply equals utilization equation. As such, this category is computed ex-post as a balancing item and is not independently estimated. If all of the other utilizations within the equation are accounted for and there is no measurement error, then the residual would be calculated as zero. The decision on whether or not to include a residual and other uses category is up to the compiling country, but the use of such a category is a simple way to acknowledge and account for small measurement errors.

Countries may also choose to utilize this category to account for quantities that are designated for any uses other than those described above. As such, this variable is more appropriately defined by what it is not rather than what it is. To the extent possible, countries should strive to account for all possible uses of a given product when elaborating a food balance sheet, but countries may wish to utilize this category to capture small amounts of product use that are otherwise unaccounted for. For example, for countries with negligible numbers of tourists, tourist food could be included under this residual category. Countries with large refugee populations may also wish to utilize this category as a way to capture food availability for refugees (they may also wish to add a designated category for "food available for refugees").

2.2.2 Additional variables

While the basic supply and utilization variables outlined above cover all of the aspects of the basic identity, composing the complete FBS—including estimates of per capita nutrient availability—requires several additional variables. The exact manner in which these variables fit together with the balance sheet will become clearer through the working of a practical example (see Chapter 4), but they are defined here for convenience.

Population

Population is defined following the UN Population Division's (UNPD) definition as, "de facto population in a country, area or region as of 1 July of the year indicated."[20] The inclusion of the term *de facto* is important, as it indicates that not only citizens, but all residents should be counted in the population. This may include refugees or resident migrant workers. It should also be noted that whatever persons are not counted under "population" should be conceptualized as "visitors" so that their food availability can be appropriately captured under tourist food. Estimates of population are needed to convert aggregate national nutrient supplies into per capita nutrient supplies.

Nutrient estimates

Nutrients are substances that the body needs in order to function properly. One of the primary motivations for compiling a food balance sheet is for the deriving of estimates of the amount of calories, fat, and protein available for consumption by a country's population. These estimates are derived from the final "food" estimates in the balance sheet for each product by applying certain conversion factors to those quantities. At present, the following nutrient-related variables are commonly derived from "food" estimates using currently available nutrient conversion tables[21]:

- Food: total calorie equivalent
- Calories per capita per day
- Food: total protein equivalent

[20] This definition is available on UNPD's Glossary of Demographic Terms, at https://esa.un.org/unpd/wpp/General/GlossaryDemographicTerms.aspx.

[21] The nutrient conversion tables used by FAO's Statistics Division in the composition of FBS are publicly available here: http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Food_security/Excel_sheets/Nutritive_Factors.xls. Because food quantities are reported in gross weight, these nutritive factors take into account the fact that the weights contain non-edible parts. It should be noted that calorie contents for some products may vary slightly from those reported in this spreadsheet. In fact, various other countries publish their own versions of nutrient conversion tables. Countries may use the FAO factors as a default, but are encouraged to investigate calorie contents of their largest food staples to ensure that food availability is being accurately estimated.

- Proteins per capita per day
- Food: total fat equivalent
- Fats per capita per day

However, additional nutrient estimates can be calculated if country-level FBS compilers wish to analyze their availability—provided that sufficiently detailed nutrient conversion tables are available. It should also be noted here that "food" estimates in the balance sheet are expressed in gross weight, such that they include edible parts. If country-specific nutrient conversion tables are specified for commodities net of inedible parts, then country-level compilers will need to first apply some sort of refuse conversion factor to calculate the weight of edible product before applying the nutrient conversions.

Activity and productivity variables

Compilers should also collect data on other relevant variables that could be necessary for the imputation of missing values. The most widely-recognized of these are activity and productivity variables. With respect to primary crops, the relevant activity variables are area sown and area harvested [most commonly measured in hectares (HA)], while for livestock, the activity variable refers to number of animals—both a total number of animals and the numbers of animals kept for specific purposes, including for dairy production, for breeding, or for draft purposes. Regarding productivity, the most common productivity indicator for crops is yield (which are often expressed in MT/HA), while for livestock, relevant productivity indicators include carcass weight (also sometimes referred to as carcass weight) and take-off (sometimes referred to as off-take) rate.

In addition to being necessary for the imputation of missing values, these activity and productivity variables can also be useful in the validation of main production variables. For example, production of crops is typically a result of a harvested area and a crop yield. To check the feasibility of the production estimate, compilers can analyze the area and yield required to achieve the stated production value—potentially including comparing yields to historic trends or agronomic potential, and analyzing harvested area in the context of current market conditions or land suitable for the production of said commodity. In the same vein, carcass weight can also serve as a simple validation check on the quantity of meat produced from a given number of animals in the livestock data domain.

Extraction rates

Extraction rates are parameters that reflect the loss in weight in the conversion (or processing) of one product into another. They are one example of a "technical conversion factor"—that is, a numerical factor that can be applied to one quantity to convert it to a different unit of measure. Extraction rates are typically expressed as a percentage, and are calculated as the amount (by weight) of derived product that is produced using a given amount of input product, as below in equation (2-6).

$$\text{Extraction rate} = \frac{\text{Quantity of output}}{\text{Quantity of input}} \quad (2\text{-}6)$$

For example, to produce 80 MT of maize flour, 100 MT of maize are needed: the extraction rate for this transformation would calculate to 80 percent, expressed as follows:

$$\text{Extraction rate} = \frac{\text{Quantity of output}}{\text{Quantity of input}} \quad (2\text{-}6)$$

$$\text{Extraction rate} = \frac{\text{80 MT maize flour}}{\text{100 MT maize}}$$

$$\text{Extraction rate} = 0.80$$

Extraction rates are key components of the balance sheet, both when calculating the production of processed products from primary ones, and when converting derived product quantities back up to primary product equivalent.

It should be noted here that several output products may be produced from a single transformation process of one input good. In these cases, it is important to check that the cumulative extraction rate is less than 100 percent, as it is not possible to produce, by product weight, more output than was originally inputted into the process.[22] Carrying forward the example of maize flour from above, the same transformation process that produces flour also produces both maize bran and maize germ.

Processing Shares

In the context of the FBS, *processing shares* are percentages of the amount of a given commodity sent to processing that are thought to be dedicated to a specific transformation process. They are often necessary for the composition of FBS because goods can be processed into an array of derived products, and the input used for the production of these derived goods is seldom known with certainty. As such, shares can be applied to the amount of a good sent to processing to calculate the amount of input into a given transformation process, and then an extraction rate can be applied to those inputted quantities to derive a production estimate. Thus, by using processing shares and extraction rates in concert, FBS compilers can arrive at an estimate of the production of derived goods when very little information exists. An example of the application of shares will be elaborated in the following section after the concept of linking primary and derived goods through commodity trees is laid out in further detail.

[22] The only exception is in cases where water, vinegar, or other products have been added during the transformation process.

2.3 Linking Supply Utilization Accounts (SUAs) to FBS through standardization using commodity trees

While FBS are typically only published at the primary commodity equivalent level in order to facilitate interpretation and policy formation, accounting for supply and use only for the primary commodity would not provide a holistic picture of how the commodity is being consumed, traded, or otherwise used after being processed into various derived products. For example, a balance solely for wheat would in most cases include little or no food use, because wheat is commonly processed into flour before it is consumed by humans, and flour is then used to produce various other derived products like bread, pastries, and pasta. Because there is both supply and demand occurring for each of these products (both primary and derived), individual accounts should be kept for both the primary product *and* all of its derived products. These accounting balances for individual products are called Supply Utilization Accounts (SUAs). For the purposes of deriving FBS, SUAs are typically organized into tables where the SUA for the primary commodity is at the top, and the SUAs for all of the products derived from that commodity follow (Table 2-1).

Table 2-1: Sample blank SUA table for paddy rice[a]

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*	*ROU*
Paddy rice	-	-	-	-	-	-	-	-	-	-	-	-
Husked rice	-	-	-	-	-	-	-	-	-	-	-	-
Milled paddy rice	-	-	-	-	-	-	-	-	-	-	-	-
Rice bran	-	-	-	-	-	-	-	-	-	-	-	-
Broken rice	-	-	-	-	-	-	-	-	-	-	-	-
Rice flour	-	-	-	-	-	-	-	-	-	-	-	-

[a]Compilers should note that this is only a sample SUA table, in that 1) not all of these products will be produced from paddy rice in every country, and 2) additional products may be produced from paddy rice as well, including rice bran oil, starch, beer, breakfast cereals, rice fermented beverages, and cereal preparations nes. For sample commodity trees, see FAO (1999).

For each primary commodity family, compilers should elaborate SUAs for both the primary commodity in question and all of its derived subproducts, which can include several different levels of processing. Continuing with the paddy rice example above in Table 2-1, primary commodity paddy rice that is processed can be both processed to produce husked rice, or it can be milled into milled paddy rice and rice bran. But once the paddy rice has been milled to produce milled paddy rice, broken rice can then be separated from that milled paddy rice, and then that broken rice can be used to produce rice flour. Each of these subsequent processing levels is linked back to the previous level through an extraction rate.

Once individual SUAs have been elaborated for the primary commodity and all of its derived products, the accounts cannot simply be added together to arrive at one primary equivalent balance. This is because the balances are elaborated by weight in MT of primary commodity-equivalents, and one MT of a derived product is not equivalent to one MT of the primary commodity.

To see why, consider a hypothetical customer who is interested in buying a large quantity of orange juice. Company X sells both fresh oranges and orange juice, and they offer to sell the customer either 100 MT of fresh oranges or 100 MT of orange juice for the same price. Furthermore, Company X offers to process the fresh oranges into juice free of charge at an extraction rate of 55 percent (that is, 0.55 MT of juice output per 1 MT of fresh orange input). FBS compilers will recognize that the customer should most definitely choose the juice instead of the fresh oranges, because 100 MT of fresh oranges will only yield around 55 MT of juice after processing. This calculation can be done by rearranging equation (2-6), as:

	$Quantity\ of\ output = Quantity\ of\ input * Extraction\ rate$	(2-7)
	$Quantity\ of\ output = 100 \text{ MT fresh orange} * \frac{0.55 \text{ MT orange juice}}{1 \text{ MT fresh orange}}$ $Quantity\ of\ output = 55 \text{ MT orange juice}$	

This non-equivalence between 100 MT of orange juice and 100 MT of oranges can also be seen by working backward from the amount of juice. In order to produce 100 MT of orange juice, about 182 MT of fresh oranges would be needed as input. Again, this calculation can be done by rearranging equation (2-6) as:

	$Quantity\ of\ input = \frac{Quantity\ of\ output}{Extraction\ rate}$	(2-8)
	$Quantity\ of\ input = \frac{100 \text{ MT orange juice}}{\frac{0.55 \text{ MT orange juice}}{1 \text{ MT fresh orange}}}$ $Quantity\ of\ input = 182 \text{ MT fresh orange}$	

This illustration underscores the concept that it is incorrect to simply add the quantities of primary and derived products together. Instead, derived products must first be converted back to their "primary commodity equivalent" (the amount of primary commodity input that would be required to produce a given amount of derived product output), and then all of the primary commodity equivalents can be added together to arrive at one overall balance. As seen in the illustration, derived products can be converted back to their primary commodity equivalents simply by dividing by the extraction rate.

This process of converting derived products to a primary equivalent so that they can be added up is called "vertical standardization." FBS for primary equivalent products are created by standardizing and adding up individual SUAs for derived products. Graphical representations of this process follow in section 2.3.1 on commodity trees, and the calculations behind standardization will be covered in greater detail in Chapter 4, but for now, we have introduced the concept and seen how it is linked to extraction rates. Following on this discussion, we can go one step further and introduce an equation that we will use in the standardization process that is based on the preceding discussion (equation (2-9)).

$$\text{Primary commodity equivalent} = \frac{\text{Quantity of derived product}}{\text{Extraction rate}} \qquad (2\text{-}9)$$

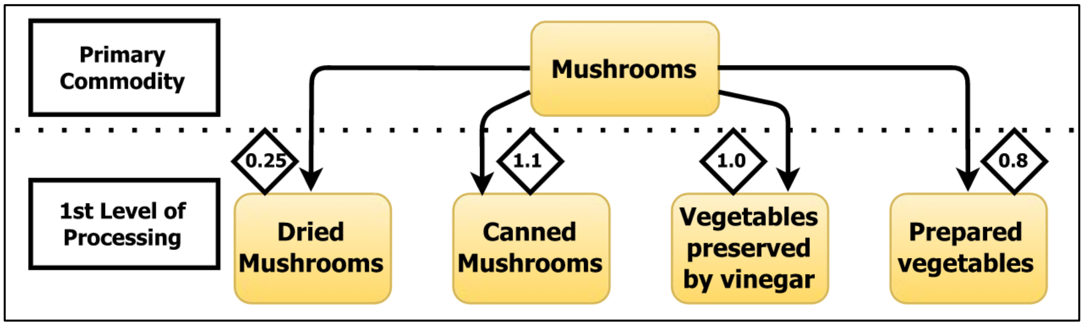
This linking of primary to derived commodities using extraction rates is fundamental to the FBS compilation process. This process is simple to understand if there is only one derived good. However, this is typically not the case—most food manufacturing commodities produce multiple outputs, and it is even possible for those outputs to undergo further transformation into second-tier derived goods. In order to better conceptualize these complicated primary/derived product relationships and better organize the work of standardization, commodities and their derived products are organized into "commodity trees." These constructs are so useful and crucial to the FBS process that a standalone section describing them is warranted.

2.3.1 Commodity Trees

Commodity trees are so-called because they "stem" from one primary product and then branch out into one or successive levels of processed products, with each level linked by extraction rates. Commodity trees are designed to be exhaustive, such that all processing uses of a particular commodity are covered. This means that they can be more or less complicated depending upon the number of derived products, the number of processing levels, and the creation of co-products during processing.

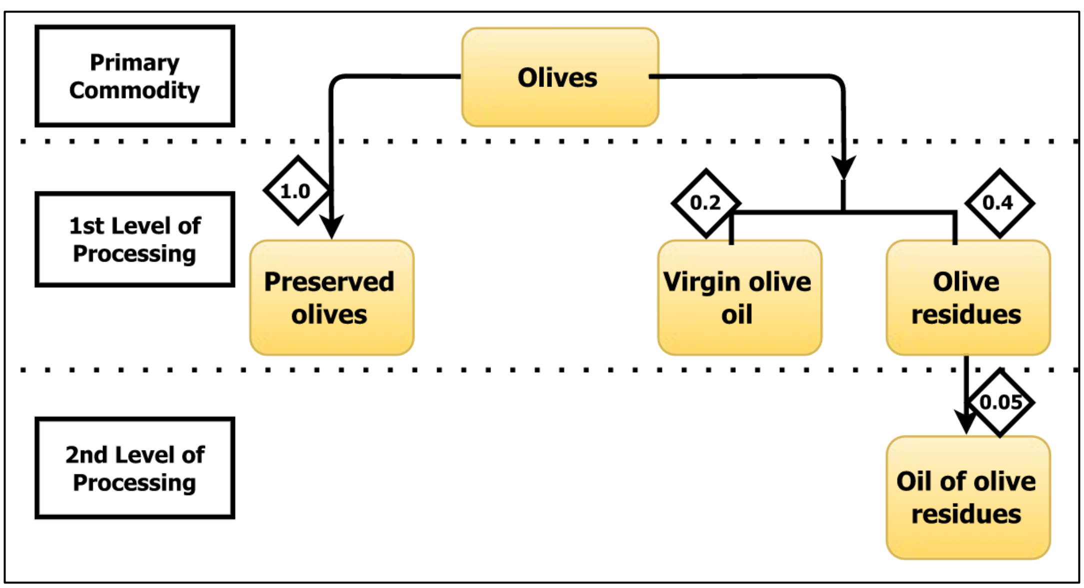
Two sample commodity trees can better illustrate some of these concepts. In Figure 2-1, we see that the primary commodity "mushrooms" can potentially be processed into four different derived products: dried mushrooms, canned mushrooms, vegetables preserved by vinegar, and prepared vegetables. Note that each arrow for all of these products is separate—quantities that enter the production process to become one of the derived goods cannot enter the production process to become any other of these goods. The extraction rate for each of these conversion processes is noted in the diamond above each derived product. In the case of dried mushrooms, the extraction rate "0.25" indicates that for every 100 MT of mushrooms that enter the process to become dried mushrooms, 25 MT of dried mushrooms will be produced. Note the extraction rate of "1.1" for the production of canned mushrooms from fresh mushrooms, indicating that for every 100 MT of mushrooms entering the canning process, 110 MT of canned mushrooms results. While this rate at first appears to be nonsensical, it is due to the fact that brine is added in the process of canning, which increases the total product weight. Compilers should note that while cases like these exist for a few products, extraction rates for most processes are less than 1.

Figure 2-1: Mushroom Commodity Tree



While transformation processes for mushrooms produce only one output from each process, compilers should note that the transformation processes for many derived products commonly have two (or even three) outputs. Multiple products that are produced from a single transformation process are called co-products. Co-products are commonly produced in the milling of cereals (flour milling also produces bran) and in oilseed crushing (where both oil and cake are produced), among others. A simple example of co-products produced from one transformation process can be found in the olive commodity tree. Olives can be either diverted to the production of processed olives, or they can be milled to produce olive oil. As can be seen in the olive oil processing branch of Figure 2-2, the extraction rate of “0.2” indicates that for every 100 MT of olives milled, 20 MT of olive oil are produced. But the presence of the co-product “olive residues” indicates that this same process also creates 40 MT of olive residues. It is important to note here that only one derived commodity from each transformation will be standardized back up to the primary commodity balance. This concept will become more evident in the product-specific balance sheet illustrations at the end of these Guidelines.

Figure 2-2: Olive Commodity Tree



Compilers at the country level are encouraged to familiarize themselves with the concept of commodity trees before beginning to compile FBS. The tree structures for nearly all commodities that undergo processing are available on FAO's website.[23] Countries are encouraged to review those trees and update them as necessary for their purposes. At a minimum, country-specific extraction rates should be added. In the absence of extraction rate estimates from the country for which the FBS is compiled, extraction rates of neighboring countries can certainly be adopted as a next-best option—particularly if the neighboring country utilizes similar technologies in their agroprocessing industries.

2.3.2 Processing shares

These example commodity trees also provide an excellent starting point for better understanding the concept of processing shares, as alluded to in section 2.2.2. Recall that a processing share is the percentage of the amount of a given commodity sent to processing that is thought to be dedicated to a specific transformation process. These shares are then used to calculate the amount of input used for a given transformation process, as below in equation (2-10). Specifically, the quantity of input required for any processed Good B is equivalent to the quantity of its source Good A that is sent to processing, multiplied by the *a priori* processing share.

$$Q\ Input\ for\ B = Q\ of\ A\ sent\ to\ processing * B's\ Processing\ share \tag{2-10}$$

There are a couple of key points to keep in mind when working with shares. First, for co-products (that is, two or more products that are outputs of the same transformation process of a single input good), their processing shares will be identical. In addition, the processing shares must sum to 100, given that all of the higher-level good sent to processing is, by definition, transformed into some other good. A short example on the use of processing shares to calculate processing input is provided below in Box 2-1.

[23] These factors are contained within the document, *Technical Conversion Factors for Agricultural Commodities*, available here: http://www.fao.org/fileadmin/templates/ess/documents/methodology/tcf.pdf.

Box 2-1: Sample exercise on the application of processing shares

Using just the first level of processing in the olive commodity tree described above, consider the following example. FBS compilers in Country A know that olives are processed domestically into both preserved olives and virgin olive oil. Although the FBS compilers know that the amount of olives sent to processing is 150,000 MT (as olives are not consumed fresh, all olives produced, net of trade, will be sent to processing), but they do not know exactly what quantities are directed to each of the different transformation processes. By using supply chain studies and consulting with market experts, the compilers learn that only a small fraction of olives are processed into preserved olives—around 10 percent, indicating that 90 percent of olives are milled for olive oil. Two points are of note here. First, co-products from the same transformation process will have identical processing shares, as they are two goods derived from a single input. In this example, that means that the processing shares for virgin olive oil and olive residues will both be 90 percent, since the two are outputs of a single transformation process. Second, the processing shares for the different transformation processes must sum to 100…that is, FBS compilers must ensure that all transformation processes are accounted for. For this example, although there are three output goods, there are only two transformation processes, so we only need to add the 10 percent processing share for preserved olives and the 90 percent processing share for olive oil as a check here.

Using this information on amount of the primary good sent to processing and the processing shares for the different transformation processes, FBS compilers can calculate the amount of input for each good, as below in Box Table 1. Applying equation (2-10), the amount of olives processed in Line A is multiplied by the processing shares for the various derived goods in Line B to calculate the amount of input for each transformation process in Line C. Notice that the inputs for co-products virgin olive oil and olive residues are identical.

Box Table 1: Sample calculation of processing input for derived olive goods using processing shares

		Olives	*Preserved olives*	*Virgin olive oil*	*Olive residues*
A	Amount Processed	150,000			
B	Processing Share		10%	90%	90%
C	Amount of Input		15,000	135,000	135,000

Using these input quantities, we can then go one step further and add the product-specific extraction rates noted in the olive commodity tree above to calculate production of the derived good by multiplying the amount of input on Line C by the product-specific extraction rates on Line D (Box Table 2). This concept of calculating production from input quantities and extraction rates is further elaborated in section 3.5.1.3 on production imputation.

Box Table 2: Sample calculation of production of derived goods using inputs and extraction rates

		Olives	*Preserved olives*	*Virgin olive oil*	*Olive residues*
A	Amount Processed	150,000			
B	Processing Share		10%	90%	90%
C	Amount of Input		15,000	135,000	135,000
D	Extraction Rate		100%	20%	40%
E	Production		15,000	27,000	54,000

2.4 The recommended balancing mechanism

In its simplest form, the exercise of compiling food balance sheets is merely using measured and imputed data to balance the supply = utilization identity. While this is a simple and intuitive construct, balancing the equation in practice is not so straightforward, for many reasons. First of all, only in a very limited number of cases are countries measuring all of the supply and demand variables. What tends to occur instead is that supply-side variables are measured, while more of the demand-side variables are imputed using statistical models or estimated by subject matter experts. If all of the demand side variables were to be estimated in order to balance out the supply side, then all of the measurement error of the supply-side variables would accumulate in the demand-side variables, affecting the accuracy and potentially increasing the uncertainty or volatility of demand-side estimates. Second, in the rare cases where all supply and demand variables are measured independently, it is not likely that the point estimates alone would lead to a precisely-balanced supply and demand equation, because of discrepancies in data sources, data collection and compilation methods, reference periods and measurement errors occurring at any of these stages. For these reasons, an overall strategy for balancing the equation must be found.

The approach that has historically been adopted is to assign one element of the equation as the balancing item—that is, a certain variable is selected to represent the combination of its estimate *and* the residual imbalance of the equation. As an example, in their balance sheets for coarse grains, USDA estimates "feed and residual" use as the balancer to the equation, such that after production, trade, stocks, food, seed, and industrial use are measured or estimated, "feed and residual" is estimated as the remainder, i.e. supply minus all the measured uses except the unmeasured feed and residual component. The variable used as the balancing item can vary depending upon the nature of the product and the country's agricultural statistical systems, but feed and food are commonly used as balancers. It should be noted here that this approach is most appropriate for statistical systems where all of the variables are measured *except* for the balancing item.

This "one balancer" approach has been popular for decades, with its main advantage being convenience (this approach means that one variable in the equation does not have to be measured). But this approach has various drawbacks as well. In the first place, in most countries, few of the utilization variables are measured, such that the supply = utilization equation will actually have more than one unknown, which can complicate the assigning of a single balancing item. Second, assigning one variable to be the balancer lumps all of the measurement error in each one of the other variables onto that single balancer variable, such that estimates for the balancing item could fluctuate wildly from year to year, which could be inaccurately interpreted by laypeople as fluctuation in the variable itself. Additionally, over time, if the errors are biased, those annual errors accumulate, such that the underlying variable that is purported to be estimated may become difficult to distinguish from the error itself. Lastly, the choice of variable to use as the balancer can be problematic. For example, using the "food" variable as a balancer would then tend to show fluctuation in food availability, which should theoretically change little from year to year. And in some cases, countries have begun to measure a variable that previously had been assigned as the balancing item, such that a new balancer must be assigned, which could potentially be even less suitable for that function. For example, consider a country that designated feed as the balancing item in their maize balance. If the country begins to survey farmers and feeding operations to derive an official estimate of feed use of maize, then a new balancer will need to be found, since feed will now be measured.

Keeping in mind these issues of accumulated error, the preferred approach to balancing the supply = utilization identity is one that not only acknowledges measurement error, but also seeks to use these errors of individual variables to help balance the overall identity. This is accomplished by specifying each of the variables as a range of possible values according to their measurement errors. In this way, the basic identity should be expanded, as:

$$Production^* + Imports^* - \Delta Stocks^* = Export^* + Food^* + Food\ Processing^* + Feed^* + Seed^* + Tourist\ Food^* + Industrial\ Use^* + Loss^* + Residual\ Use^* \quad (2\text{-}11)$$

where:

$$Production^* = Production \pm e(Production)$$
$$Imports^* = Imports \pm e(Imports)$$
…and so on for the other variables.

In contrast to the point estimates of the variables described previously in equation (2-4), the terms here in equation (2-11) represent the possible range, or tolerance interval, of each of the variables, which is specified as the sum of the original expected value for that variable and the measurement error of that variable, e.[24,25] Further guidance on the estimation of these tolerance intervals is detailed in section 3.4.2.3, but for now, interpretation of this equation will be helped by emphasizing that variables that are measured (by surveys, for instance) will likely have smaller tolerance intervals than the variables that are imputed or estimated. The underlying principle of a statistically sound balancing method is that those elements with the largest tolerance intervals should be those where the bulk of the imbalance in the identity is distributed.

Given this interpretation of the supply=utilization identity, the balancing process then becomes merely a matter of distributing the equation's imbalance. Several approaches to this imbalance distribution are offered below in section 2.4.1, but they all follow three basic steps:

<u>Step 1. Calculate the imbalance from the supply = utilization identity, where the imbalance for a given commodity in the country in question, *Imbalance*, is defined as:</u>

$$Imbalance = Production + Imports - \Delta Stocks - Exports - Food - Food\ Processing - Feed - Seed - Tourist\ Food - Industrial\ Use - Loss - Residual\ Use \quad (2\text{-}12)$$

It is important to note that in this step, the imbalance is calculated from the variable point estimates. No accounting has yet been made for the measurement error…that follows in Step 2. As noted above, regardless of the method chosen to distribute the imbalance throughout the identity, Step 1 will still need to be performed and will not change in any of the proposed methods.

<u>Step 2. Distribute the imbalance throughout the supply = utilization identity:</u>

This step can be more or less complicated or computationally demanding, and it is here that the methodological approaches of countries may differ. The optimal approach will consider all of the

[24] In this context, "measurement error" includes both non-random error (that is, systematic errors that always bias the estimates in a particular direction) and random error (including sampling errors, which are not biased in any one direction).
[25] Note also that food processing is not included in this identity. That is because, at the point where balancing occurs (after standardization and aggregation), food processing will in most cases already have been dropped from the balance to avoid double counting. More details on this process can be found in Chapter 4.

information contained within the underlying variable estimates—that is, balancing will be achieved by using the information contained in the tolerance intervals to distribute the equation's imbalance throughout the variables.

Additionally, it is important to note here that the direction of adjustments in the point estimates will depend upon the sign on the imbalance calculated in Step 1. That is, if the calculated imbalance is positive (indicating that supply is greater than utilization), then any adjustments in the supply variables "production" and "imports" should be downward, while adjustments in the remainder of variables (the utilization variables, plus stock changes given its opposite sign) must be positive. In contrast, if the calculated imbalance is negative (that is, utilization is greater than supply), then adjustments in production and imports should be positive, while adjustments in the remaining variables should be negative.

Step 3. Check that all balanced quantities are within any set bounded values, and rebalance if necessary:

In some instances, the balancing process will produce results where certain balanced quantities are estimated outside of bounded (or likely) values. In these cases, this problem is resolved by setting the value in question at the boundary level and also assigning that value a tolerance interval of zero (so, a fixed, "balanced" value), and then repeating Steps 1 and 2 in order to redistribute the imbalance. For example, if there is an upper bound for industrial use of 50 MT because of available processing capacity, but the balancing calculation estimates industrial use at 100 MT, then the value for industrial use is set at the bounded level of 50 MT with a tolerance interval of zero, and the balancing calculation is performed again.

2.4.1 Approaches to distributing the imbalance at FBS level

Among the many methods that can be used to distribute the imbalances, some of the most common are presented here, along with what can be considered as the first best or "gold standard" approach. The choice by countries on which approach to utilize may be influenced by a country's statistical capacity, time constraints, desire for replicability, or structural constraints. The advantages and disadvantages of each of these approaches is included below, along with a general description of the approach.

2.4.1.1 Recommended Approach—Distribute imbalance proportionally based on aggregated error

The recommended imbalance distribution approach for country-level FBS compilers attempts to use the information about the uncertainty of point estimates to proportionally distribute the imbalance; that is, the variables with the highest tolerance intervals (considered the least reliable) are adjusted proportionally more than variables with a lower tolerance interval. The necessary steps in this method include:

Step 1: Use tolerance interval percentages and point estimates to quantify the error of each variable. If the quantity for a given variable should remain fixed because it is an official estimate, a tolerance interval of zero can be assigned.

Step 2: Sum up the individual errors of each variable to calculate an aggregated error for the equation.

Step 3: Calculate the proportion of the aggregated error for each of the elements.

Step 4: Distribute the imbalance proportionally, keeping in mind that a negative imbalance indicates that production and import variables must be increased and the remaining variables must be reduced from their pre-balanced values, while the opposite is true for a positive imbalance.

Step 5: Ensure that any constraints are met, and recalculate if necessary.

A simple example case balancing sorghum supply and utilization in Country Z can be used to illustrate this method (compilers will note that several variables have been eliminated from this short example, for simplicity's sake). FBS compilers in Country Z have produced the following unbalanced supply and utilization table for sorghum in their country (for the purposes of this illustration, sorghum is not consumed as food or processed in Country Z, but is mostly destined for feed, and the country does not utilize a residual and other uses category). Note the point estimates on Line A and the *a priori* tolerance intervals on Line C below in Table 2-2. Given the data on Line A, the imbalance in the supply and demand account is calculated in Line B (calculated as $Imbalance = Production + Imports - Exports - Feed - Seed - Loss$, or $892 + 307 - 48 - 1061 - 3 - 44 = 43$).

Table 2-2: Unbalanced sorghum supply and utilization in Country Z

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Feed (4)*	*Seed (5)*	*Loss (6)*	
A	Sorghum	892	307	48	1061	3	44	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6]							43
C	Tolerance Interval (in %)	±15.0%	±0.0%	±0.0%	±40.0%	±15.0%	±15.0%	

Beginning from this table, the first step is to quantify the error into units instead of percentages. This can be done by multiplying the values in Line A by the percentages in Line C to arrive at the values in Line D (Table 2-3).

Table 2-3: Step 1 – Unbalanced sorghum table with quantified error

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Feed (4)*	*Seed (5)*	*Loss (6)*	
A	Sorghum	892	307	48	1061	3	44	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6]							43
C	Tolerance interval (in %)	±15.0%	±0.0%	±0.0%	±40.0%	±15.0%	±15.0%	

D	Error [D=A*C]	133.8	0	0	424.4	0.5	6.6	

Next, the individual error estimates for each of the variables is added up to arrive at an estimate of the equation's aggregated error. In this case, all the values highlighted in green on Line D are added together to arrive at the aggregated error of 565.3 on Line E (Table 2-4).

Table 2-4: Step 2 – Sum individual variable errors to calculate aggregated error

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Feed (4)*	*Seed (5)*	*Loss (6)*	
A	Sorghum	892	307	48	1061	3	44	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6]							43
C	Tolerance interval (in %)	±15.0%	±0.0%	±0.0%	±40.0%	±15.0%	±15.0%	
D	Error [D=A*C]	133.8	0	0	424.4	0.5	6.6	
E	Aggregated error [E=D1+D2+D3+D4+D5+D6]							565.3

From here, the proportion of the aggregated error that belongs to each one of the individual variables is calculated in Line F (Table 2-5). This is done by dividing the error of each individual variable by the aggregated error estimate. For example, the proportion of aggregated error that is attributed to production in this scenario is 23.7 percent ($\frac{133.8}{565.3} = 0.237$).

Table 2-5: Step 3 – Calculate proportion of aggregated error for each individual variable

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Feed (4)*	*Seed (5)*	*Loss (6)*	
A	Sorghum	892	307	48	1061	3	44	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6]							43
C	Tolerance interval (in %)	±15.0%	±0.0%	±0.0%	±40.0%	±15.0%	±15.0%	
D	Error [D=A*C]	133.8	0	0	424.4	0.5	6.6	
E	Aggregated error [E=D1+D2+D3+D4+D5+D6]							565.3
F	Proportion of aggregated error [F=D/E]	23.7%	0.0%	0.0%	75.1%	0.1%	1.2%	

Next, the imbalance in the equation is assigned proportionally based upon these percentages. That is, the total imbalance in the equation (in this case, 43), is proportioned across the different variables according to their share of the aggregated error: 23.7 percent of the aggregated error is accounted for in production, zero percent is accounted for in imports, zero percent is accounted for in exports, 75.1 percent is accounted for in feed, 0.1 percent is accounted for in seed, and 1.2 percent is accounted for in loss (Table 2-6). To calculate how much the unbalanced quantities should be adjusted by, the imbalance in Line B is simply multiplied by the percentages in Line F to arrive at the adjustments in

Line G. Then the unbalanced values in Line A are adjusted by the values in Line G to arrive at the balanced equation in Line H. Recall that because there is a positive imbalance, supply variables production and imports must be adjusted downward, but the utilization elements should all be adjusted upward. If the imbalance were to be negative, then production and imports would instead be adjusted upward and the remaining elements adjusted downward.

Table 2-6: Step 4 – Distribute the imbalance proportionally

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Feed (4)*	*Seed (5)*	*Loss (6)*	
A	Sorghum	892	307	48	1061	3	44	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6]							43
C	Tolerance interval (in %)	±15.0%	±0.0%	±0.0%	±40.0%	±15.0%	±15.0%	
D	Error [D=A*C]	133.8	0	0	424.4	0.5	6.6	
E	Aggregated error [E=D1+D2+D3+D4+D5+D6]							565.3
F	Proportion of aggregated error [F=D/E]	23.7%	0.0%	0.0%	75.1%	0.1%	1.2%	
G	Adjustment [G=B*F]	10.2	0.0	0.0	32.3	0.0	0.5	
H	Sorghum adjusted values [for (1) and (2), H=A-G, for remaining, H=A+G]	881.8	307.0	48.0	1093.3	3.0	44.5	
I	Imbalance for H [I=H1+H2-H3-H4-H5-H6]							0

The final step in this method is to ensure that any constraints are met and recalculate if necessary. In this particular simplification, no values violate any constraints, so no rebalancing is necessary and the account can be considered to be balanced.

Although this approach requires several steps, it is not computationally demanding and can easily be replicated. This approach also takes into account the imprecision of the point estimates by calculating the adjustments based on confidence in the individual estimates (as expressed by the tolerance interval), using all available information to arrive at a balanced account. At the same time, the balanced equation produced by this approach will vary slightly depending upon the *a priori* assigned tolerance intervals. The final limitation to this method is that it may not be feasible for countries who wish to publish detailed accounts for derived products—because the balancing occurs here at the primary equivalent, it's not straightforward to go back down the tree and recreate the SUAs.

2.4.1.2 Assigning small, positive imbalances to a residual use category

An additional alternative approach that can be used (ideally in situations where the imbalance is small and positive) is the use of the "Residual and other uses" category, rather than the distribution of the imbalance across variables. This approach on its own could be utilized in cases where a positive imbalance is below an *a priori* threshold (for example, less than 5 percent of total supply or total demand). In this way, the error does not accumulate in any of the other variables, and it is dealt with in a transparent way. At the same time, this approach should not be used for imbalances greater than a small threshold level, as imbalances of that size would indicate either that some utilization is being missed, or the estimation of at least one utilization is very imprecise. In those situations, countries may wish to continue to utilize "residual and other uses" to account for the imbalance up to the established threshold, and then re-distribute the remaining imbalance with proportional balancing. However, it should be emphasized here that if the technical working group determines that the imbalance is very large, leaving a sizeable quantity of utilization unexplained, then data of all the other utilizations should be checked (and, potentially, other data sources should be consulted).

2.4.1.3 Single balancer approach

The single balancer approach—where one utilization variable is calculated as the remainder after all other utilizations are accounted for—remains an option that countries may consider when elaborating their country-level FBS. However, particularly for countries where multiple variables are not measured, country-level FBS compilers are encouraged to try the proportional balancing approach first, as that approach prevents the systematic accumulation of error in one variable over time, allows the quality of the data in each of the variables to be recognized in the final overall commodity balance, and permits the imposition of certain feasibility constraints. If, for whatever reason, country-level FBS compilers decide that the single balancer approach is the most feasible for their particular circumstances, they should be aware of and broadcast the caveats and shortcomings of estimates produced using this methodology.

Additionally, it should again be emphasized that not all variables are appropriate as balancers in the single balancer approach, and the degree of appropriateness may even differ from product to product. For example, feed may be considered as the preferred balancing item for the maize balance sheet, but for a commodity like apple juice that likely is never used as feed, it will not be possible to use feed as the balancer, and food use will instead be the preferred balancer.

2.4.2 Constraints on the balancing process

Step 3 of the recommend balancing approach alludes to the idea that the balancing process should take into account certain constraints on the values—a topic which is explored in further detail here. While some constraints may be universal across countries and products, country compilers may find that they need to impose additional constraints based on conditions inside their country (as in the above example about processing capacity). Because it is not possible to foresee all possible constraining situations, only the universal constraints are explored below.

Row constraint

The most obvious constraint on the process of allocation of the imbalance is that supply for each commodity must be equal to utilization for that commodity—referred to as a "row constraint." As an extension of this row constraint, a country's exports of a given commodity cannot exceed their supply of that commodity. Mathematically, this can be expressed as:

$$Production + Imports - \Delta Stock > Exports \quad (2\text{-}13)$$

This particular row constraint can be a useful way of either identifying errors in trade data, or else alerting country-level FBS analysts to the fact that production of a new commodity is taking place inside their country. After all, a country cannot export a product if they are not producing it or importing it from elsewhere before exporting it (this latter case would technically be defined as a re-export, but exports may not always be clearly differentiated from re-exports in trade data reporting).

Column constraints

Compilers should also be aware that constraints may need to be imposed on changes in quantities over time. Two examples of this type of constraint should be highlighted here: single-year constraints, and multiple-year constraints. With respect to single-year constraints, compilers should note whether or not year-to-year changes are within the bounds of feasibility. One example is changes in food availability and derived DES estimates. Barring catastrophe (war, natural disasters, etc.), DES estimates are unlikely to vary greatly on an annual basis, with aggregate changes of 100 calories per capita considered the absolute upper bound. Stocks represent another obvious example of the need for a single-year column constraint, as subtraction from stocks in a given year cannot be greater than the overall level of stocks.

Multiple-year column constraints should also be considered. In this case, stocks are again the most prominent example, as it is considered highly unlikely that a country would either add to stocks or take away from stocks for many years in a row. If compilers find this to be the case, then they should consider imposing a bound on the stocks changes in the balancing process to ensure that the pattern is discontinued.

"Vertical standardization" constraint

Particularly in cases where production, trade, and other utilizations of derived products come from official data, it may be useful for countries to also specifically apply a "vertical standardization" constraint. That is, they must ensure that there is a sufficient quantity of primary product sent to processing to ensure that each of the derived product accounts do not have any negative discrepancies (the "row constraint" mentioned above).

If countries find that they don't seem to have enough input for the production of derived commodities, this is most commonly an indication that the estimated extraction rate may be too low (thus, a lower amount of input would be necessary to generate the same amount of output).

Imbalance exceeds aggregate measurement error

Country-level FBS compilers may identify cases in which the imbalance in the equation exceeds the aggregate measurement error. These instances can result from much larger error in one of the point estimates than is indicated by the assigned tolerance intervals. This situation is not problematic per se in any of the approaches outlined above. However, it does indicate that that the uncertainty levels are set too conservatively (more guidance on setting tolerance intervals is offered in section 3.4.2.2). As such, these cases are an opportunity for countries to re-examine official estimates for their accuracy, and in some cases to consider assigning a higher tolerance interval to those estimates if their precision is determined to be questionable.

2.5 Summary

In this chapter, we have attempted to outline the basic approach to constructing a food balance sheet. Food balance sheets are based on an overall supply = utilization identity, where accounts of primary and derived products are organized into commodity trees and linked by extraction rates. Individual supply utilization accounts of derived products are filled and balanced, then aggregated up to the primary commodity equivalent level. Accounts at the primary commodity equivalent level are then balanced. The recommended approach to balancing the account at the primary commodity equivalent level involves taking into account the precision of the point estimates by using tolerance intervals to distribute the imbalance in the equation. Compilers should use this knowledge—that both expected value and tolerance interval are needed as inputs—in their search for reliable input data. These concepts are covered in more detail in Chapter 3. A practical example utilizing the balancing mechanism will follow in Chapter 4.

3

Data for FBS compilation: considerations, sources and imputation

3.1 Overview

The bulk of the work of compiling an FBS involves the compilation and reconciliation of data. This process begins with an exercise in determining which products are most important to include assessment of data availability, including identifying all possible data sources, assessing data quality, and formulating a plan for filling in missing or unknown values. This assessment is fundamental to the construction of country-level FBS, as it allows the user to assemble the expected values of all the variables in the balance and assign an *a priori* tolerance interval based on the quality of the data. Additionally, this process improves the user's understanding of the dynamics of each supply chain considered in order to ensure that all uses are accounted for. Furthermore, this process facilitates the building of a network of experts that can be consulted when doubts arise and can assist in validation of the final product.

In the process of compiling data, country-level FBS compilers will consult a variety of sources, based on the variable and product in question. Guidance as to potential sources at the disposal of country-level FBS compilers is provided in section 3.5 to facilitate this search. This section also contains suggestions on modelling or estimation approaches that country-level FBS compilers may find useful when attempting to impute or estimate missing values.

3.2 Assembling a Technical Working Group and assigning roles

As emphasized in Chapter 1, the ideal setup for FBS compilation is a dedicated Technical Working Group (TWG) involving relevant actors from government institutions (potentially including the NSO, Ministry of Agriculture, Customs Office/Ministry of Trade, Ministry of Industry/Commerce, and the Ministry of Health), research organizations, industry groups, and producer groups. Thus, the first step toward FBS compilation is the assembling of such a TWG. This group should include all organizations that produce cross-commodity data that will be included in the balance sheet, but the effort should most likely be led by a group within the Ministry of Agriculture or the National Statistical Office. Because institutional structures differ so substantially between countries, however, it is not possible to advise with certainty which organization should lead this effort. Countries may find that it is useful to put together commodity-specific committees to analyze the balances for certain products as well, but it is recommended that an overarching FBS TWG be assembled to bring all of the individual primary-equivalent balances together at the end.

Once the TWG has been established, the roles of each organization should be defined. Some TWGs may prefer that the whole start-to-finish process take place among the entire TWG, for example. Other TWGs may wish to assign the responsibility of producing data for certain components or variables in the balance sheet to one institution or the other, with the TWG only meeting to validate the final output. Again, these arrangements will depend upon the resources, technical capacities, and desires of the compiling country, but it is highly recommended that final approval of the national FBS be endorsed by a TWG representing a collaboration of stakeholders.

3.3 Determining product scope

Although FBS should strive to be comprehensive and include all products consumed within a country, the reality is that, for many countries, it may not be possible or practical to elaborate balances for every single product. For this reason, it is recommended that FBS compilers first determine the product scope of their national-level FBS before endeavoring to produce an FBS, with the ambition of reaching an approximation of national food availability. As a general rule, countries should strive to cover products that represent at least 90 percent of total caloric consumption, as identified in household consumption surveys. At the same time, compilers should seek to ensure that at least the most-consumed commodities in each commodity group are represented. In this exercise, data availability may be one constraining factor.

Although compilers may begin with an abbreviated list of commodities, they are encouraged to add products over time, as access to different source data increases and capacity for FBS compilation within the country improves. Country-level compilers are both welcomed and encouraged to use FAO's list of commodity items and FBS aggregates as a starting point in determining which products are most relevant for domestic FBS compilation.[26]

3.4 Data assessment and other preliminary considerations

After the scope of the products to be included in the FBS has been determined, the next step of data assessment is crucial to the FBS compilation process, as it will document all the data sources used and help country-level FBS compilers to ensure data comparability. This assessment begins with the inventory of potential data sources for all the relevant variables for each commodity, accompanied by an inventory of various attributes of each data series. This assessment should document the basic accessibility of the data (including the source of the data, its typical release date and/or the frequency of its publication), attributes that establish the comparability of the various data series (including product classification, unit, and reference period), and an assessment of the quality of the data, largely

[26] The list of aggregates and their component commodities is available at:
http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Food_security/Excel_sheets/Commodities_which_are_aggregated_or_standardized.xls.

for the purposes of assigning a tolerance interval for each variable. Before providing guidance on the assessment itself, the concepts of data comparability and data quality will first be explored in further detail.

3.4.1 Data comparability

Throughout the process of gathering data, users must keep in mind that in order for an "apples-to-apples" comparison in the context of the balanced supply and utilization equation, data need to be fully comparable. This comparability includes various levels, including comparability of the item itself, comparability of the chosen reference period, and comparability of the units in which the item is measured. Each of these is explored in further detail below.

3.4.1.1 Ensuring product comparability through the use of statistical classifications

Perhaps the most obvious starting point for data comparability is to ensure that the products being compared are actually the same. As an example, production quantities for rice can be reported on either a paddy (unmilled) or milled basis. If production were to be recorded on a paddy basis in the supply and utilization balance, but another variable such as tourist food were to be recorded on a milled basis, an unintentional error would be introduced in to the balancing process that could easily have been avoided if an analyst had checked to ensure that the products were strictly comparable. It should be evident then why users must be aware of these types of distinctions during the process of compiling data.

To avoid these kinds of situations, it is advised that countries express quantities of products using some sort of international statistical classification structure. Not only will utilizing such a structure ensure the comparability of products within a balance sheet framework, but will also facilitate the comparability of data between countries that utilize the same structures. Countries are of course free to develop their own statistical classification schemes, but numerous international statistical classifications already exist for agricultural statistics that can, in most cases, be adapted to fit the needs of any given country.[27]

For the purposes of these Guidelines, two classification structures should be highlighted—the UN Central Product Classification (CPC) and the Harmonized Commodity Description and Coding System (HS).

UN Central Product Classification

The CPC is an international statistical classification for products that is maintained by the UN Statistics Division (UNSD). The most recent version of the CPC (Version 2.1) includes an annex on agricultural statistics that was developed by FAO in order to facilitate agricultural data collection and harmonization efforts. FAO uses this version of the CPC (Version 2.1 Expanded) for its production surveys, and production data is available in both CPC and the designated FAO production

[27] For more information on international classifications for agricultural statistics, please consult Global Strategy (2015b).

classification (FAOSTAT Commodity List, also known as FCL[28]) on FAOSTAT.[29] It should be noted here that the two lists have a 1-to-1 link for nearly all commodities. For this reason, adoption of the CPC at the country level would benefit comparability of both in-country FBS with FAO-produced FBS, as well as in-country FBS with those of other countries.

The CPC organizes products into a five-level hierarchical structure, with the CPC expanded adding two more digits at the lower level in order to better account for some minor agricultural products. This structure is well-suited to the work of FBS compilation, since products are aggregated at the primary equivalent level in the commodity trees covered in section 2.3.1. An additional benefit of the CPC is that it is mapped to the HS classification for international trade (covered below), which greatly facilitates the comparison of production and trade data within the FBS context.

Harmonized Commodity Description and Coding System

The Harmonized Commodity Description and Coding System (commonly referred to as the *Harmonized System*, or HS), is a classification developed by the World Customs Organization. The HS is the most widely utilized classification in the context of international trade, as it is used by more than 200 countries and covers 98 percent of international merchandise trade (Global Strategy, 2015b). This classification is updated every five years, with the 2017 version (HS 2017) having entered into force on January 1, 2017.[30]

The HS is also a hierarchical structure, comprised of 5,000 six-digit product groups contained within ninety-seven chapters.[31] As with the CPC, expansions on this system are also possible. Indeed, many countries add further classifications at the 8-digit, 10-digit, or even 12-digit levels.

The use of the HS as a format for trade data within the FBS context is recommended, primarily for data comparability purposes (given that more than 200 countries are already utilizing this classification) and because of its ease of concordance with the CPC, as noted above.[32] FAO has also produced direct HS6 to FCL concordance tables (publicly available on the FAO website), which can facilitate classifications of imports and exports during FBS compilation.[33] As with the CPC to FCL classifications, most concord on a 1-to-1 bases.

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[28] The complete FCL, and a search for FCL code by keyword, are available at: http://www.fao.org/economic/ess/ess-standards/commodity/en/.

[29] The most up-to-date correspondence table between FCL and CPC is available at: http://www.fao.org/fileadmin/templates/ess/classifications/Corr_11Jan2017.xlsx.

[30] The full HS 2017 is available from the World Customs Organization's website. See: http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx.

[31] Because data in the HS is harmonized at the six-digit level, most FBS are compiled using trade at the 6-digit level (although an FBS commodity may include trade flows of multiple HS6 codes). For some countries and commodities, compilation of FBS at a more detailed level would be possible if data is collected at a more detailed level.

[32] The correspondence table between the HS 2012 and CPC Ver.2.1 can be found at http://unstats.un.org/unsd/cr/registry/regso.asp?Ci=81&Lg=1.

[33] The correspondence table for FCL to HS6 can be found at http://www.fao.org/economic/ess/ess-standards/commodity/item-hs/en/, while the complementary table of correspondences for HS6 back to FCL can be found at http://www.fao.org/economic/ess/ess-standards/commodity/hs-item/en/.

In some cases, either multiple FCL or CPC products are covered under a single HS6 category, or multiple HS6 products feed into a single FCL category. This typically occurs for "baskets" of similar commodities that are not elsewhere specified (nes), such as other fresh fruits, fat preparations nes, or food preparations nes. In these cases, sometimes countries have more specific 8- or 10-digit HS codes that can facilitate the linking of a 1-to-1 comparison. In other cases, it may be necessary for country-level compilers to more carefully research exactly what types of products predominate in those identified basket categories. This may be accomplished by speaking with customs brokers, analyzing customs declarations, or even by consulting mirror trade data from other countries that may offer a more detailed product description at the HS8 or HS10 level. If compilers are specifically trying to categorize import data for which one HS is mapped to many FCLs/CPCs, it may be possible to use country of origin as an additional strategy to discriminate what products may be coming in under a basket category. For example, the HS6 code 0810.90 covers "Other, other fresh fruit," which includes stone fruit nes, pome fruit nes, tropical fruit nes, and other fruit nes. An analysis of the source countries for trade flows under 0810.90 could then be cross-referenced with reported production from each source country to formulate an approximation of what kind of fruits each trade flow can be classified as.

3.4.1.2 Common units

Aside from ensuring that compiled data for the different FBS variables refer to the same products thru the usage of an international statistical classification structure, it is also important to keep in mind that product values must be reported in common units so that the equation can be balanced. Many countries report production for the majority of agricultural products in terms of MT, but users should also be mindful that some quantities can be reported in 1,000 MT. Adjustments should be made accordingly in the process of compiling the balance sheet to ensure the usage of a common unit.

In some countries, however, agricultural production is measured and reported in other units specific to those countries. As two examples, El Salvador reports production of most crops in terms of quintals, and the United States reports production for most grain crops in terms of bushels. At the same time, most trade data is reported in MT, and most calorie conversion tables are elaborated in terms of calories per kilogram. For this reason, it is recommended that countries elaborate balance sheets in MT. Aside from ease of converting quantities into calories equivalents, compiling balance sheets in MT has other advantages—primarily that country balance sheets compiled in MT are directly comparable to those compiled by FAO, and are more likely to be comparable to balance sheets compiled by other countries as well. At the same time, it is possible that balance sheets compiled in other units may be more easily understood by stakeholders within the country. Whichever unit is chosen, compilers should be careful to convert all data expressed in different units of measure using internationally-accepted conversion rates.

Lastly, for some liquid products, certain variables in the balance sheets may be reported in litres (L), while other variables may be reported in MT. For these conversions, it should be noted that compilers must use conversion factors specific to the product in question (due to differences in densities) in order to avoid introducing additional error to the estimates. FBS compilers should consult their relevant national authorities to determine applicable conversion factors for liquid products. Absent data from national authorities, approximate densities for similar products are available via the FAO/INFOODS Database.[34]

3.4.1.3 Reference period

After the comparability of the item and the unit of measurement have been ensured, compilers should decide upon a consistent reference period for the balance sheet. Common reference periods include the marketing year (also sometimes referred to as the agricultural year, harvest year, or crop year), the calendar year, and the fiscal year (also sometimes referred to as the financial year or budget year): the marketing year begins in the month when the bulk of the crop in question is harvested, the calendar year begins in the first month of the calendar (January-December for countries observing the Gregorian calendar), and the fiscal year begins whenever defined by the country in question. For reasons of data comparability, it is recommended that countries compile their balance sheets on a calendar year basis. However, depending upon agricultural data collection programs, compiling sheets on a marketing year or fiscal year may be more feasible. Each possibility is detailed below.

Marketing year

Marketing years have the advantage that they closely follow the cycle of each season, such that the utilization of each year's production follows a logical conceptual temporal flow, ending with the harvest of the subsequent season. But this temporal aggregation can also be problematic if different crops are harvested at different points in the year—say if the balance sheet for corn is compiled on an April-March basis, but the balance for oranges is compiled on a July-June basis, then the calories from the two products cannot be added together for the purposes of arriving at a total DES estimate. For this reason, marketing years tend to be more appropriate for the estimating of single, stand-alone commodity balances rather than an overall FBS.

An additional complication with the marketing year involves countries that experience multiple harvests. For example, in several tropical countries, rice can be harvested at three separate times of the year, which complicates the process of defining a "marketing year" for its production. The last consideration for using marketing year data is that trade data is often by default aggregated into calendar years. For most countries, trade data is also simultaneously published on a monthly basis, such that compilers could aggregate the monthly data in such a way as to fit the marketing year if they saw fit.

Calendar year

Each of the limitations delineated for the crop year can be said to be points in favor of compiling food balance sheets on a calendar year—calendar years provide a "neutral" reference period that is consistent across commodities, and calendar years are the default reporting periods for trade data. Additionally, calendar years are consistent across countries, which facilitates greater data comparability. Indeed, FAO's global coverage of FBS are calculated on a calendar year basis for

[34] The FAO/INFOODS Database can be accessed here: http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/.

precisely this reason. The last advantage of using calendar years for FBS compilation is to facilitate the comparability of FBS data with national accounts data, which are typically compiled on a calendar year basis (although they can also be compiled on a fiscal year basis).

The only limitation of using the calendar year as a reference period is that it can be difficult to understand conceptually. Countries should follow this general rule when converting marketing years to calendar years—production should be assigned to the calendar year in which most of the crop will be consumed. This should be a relatively intuitive construct for crops whose marketing years start either late or early in the year. For example, if the marketing year begins in February 2015, then production should be assigned to calendar year 2015. Likewise, if the marketing year begins in December 2015, then production should be assigned to calendar year 2016. The complications occur for crops whose harvests occur toward the middle of the calendar year—particularly May-August. In these cases, countries should consider both the reliability of their estimates on stocks, and the potential implications on trade of assigning production to one calendar year or another. For example, if a crop is harvested in June 2015, but due to the nature of the supply chain (potentially including drying, processing, storage, and aggregating) it is not exported until February 2016, then country-level FBS compilers have two options: they can either assign the production to 2015 when the crop was harvested and carryover the production into the following calendar year using stocks, or if estimating stocks is problematic, they can instead assign production to calendar year 2016 to ensure sufficient exportable supplies. In making these determinations, it would also be beneficial for country-level FBS compilers to consult industry experts for their opinions.

Fiscal year

The primary motivation for compiling FBS based on fiscal year is if the country is collecting agricultural production and other data on a fiscal year as well (this is the case in Nepal, for example). Because fiscal years are periods of time defined by governments for accounting purposes, they face some of the same advantages of the calendar year: they provide a neutral reference period (which is particularly helpful in countries where multiple crops are harvested), and the data are compatible with national accounts compiled on a fiscal year basis. At the same time, fiscal year FBS may be difficult to understand conceptually (depending upon when the bulk of the crop is harvested and traded, as above). An additional drawback to fiscal year FBS compilation is that fiscal years vary by country, such that comparing fiscal year FBS across countries is difficult.

3.4.2 Data quality, flags, and tolerance intervals

Food balance sheets by definition are analytical datasets, comprised of data extracted from a variety of different sources. This is of course the nature of the work, but compilers should also recognize that data taken from different sources will likely be of varying degrees of quality. For example, official sources (like government agencies) will likely have a publicly available methodology detailing how certain data was collected. Other sources may be less transparent about how their data was derived, and their processes may not be subject to the same rigorous standards. For this reason, there is a preferred hierarchy of data sources: official data, followed by semi-official data, data imputation, and data from expert estimation. Each of these categories is detailed below.

3.4.2.1 Hierarchy of data sources

Official data

For each variable in the framework, official data sources are always preferred for expected values, as it is assumed that such data are most likely to have been compiled according to sound statistical methodologies. However, for many countries, there is not a single "official" estimate, as multiple agencies publish data relating to agricultural output. For example, if a National Statistics Office (NSO) publishes an estimate of a country's total maize production, but the Ministry of Agriculture releases a different estimate of maize production, then there will be confusion on the part of both the FBS compiler and external users as to which is the *real* "official" production estimate. To avoid this type of confusion, it is suggested that the process of compiling food balance sheets be preceded by the reconciliation of estimates between different official sources. Optimally, only one agency would be tasked with producing an "official" estimate. In cases where this may not be possible for whatever reason, it is recommended that different sources explore the methodological reasons for the divergence in the estimates and come to some agreement about which number is most appropriate for the purposes of compiling food balance sheets. These Guidelines cannot recommend one source over another, as the situation inside any given country may mean that the estimates of one agency may be more appropriate for FBS compilation than another. However, it is recommended that the National Statistics Office coordinate data reconciliation activities as part of an integrated national statistical framework.

Semi-official data

In instances where official data are not available (particularly for utilization variables), it may become necessary to consult and consider alternative sources. These sources—deemed "semi-official"—may include industry groups, trade publications, or investigations conducted by product supply chain experts. In ideal circumstances, the expertise uncovered in a search for alternative sources could help to inform/reform processes for collection of official data for the variable in question, as semi-official sources may not collect data with the same regularity as on official source.

Imputation

When no official or semi-official sources can be found for the data in question, the next alternative is the model-based imputation of missing data. It should be noted that in most cases, data imputation relies on a historical data series, such that the quality of imputed data will highly depend upon the quality of the source data—often referred to as the "garbage-in, garbage-out" phenomenon. Separate imputation approaches are suggested for different variables in the balance sheet. An effort has been made in these Guidelines to be as comprehensive as possible in the listing of various approaches, but users should keep in mind that other methodologies may be more appropriate for certain products in their home countries.

Expert estimation

The lowest quality level of source data is that derived through expert estimation. Expert estimation is different from imputation in that it relies not on a model, but instead on expert judgment. Because this approach is not based on statistical methodology and is not replicable, the error on values estimated by experts is assumed to be high.

3.4.2.2 Application of flags to denote data source

Using data from a variety of sources is very common in the compilation of food balance sheets. But as can be seen in the above discussion about the quality hierarchy of data sources, not all data in the FBS should be assumed to be of equal quality. For this reason, it is recommended that countries not only keep track of the data sources used, but also publish a flag denoting the data source alongside the final estimates. This allows users to see, at a glance, the source of the data, and to understand that some data points may be more reliable than others. Additionally, the flags can be used to assist compilers in the process of assigning *a priori* tolerance intervals for the purposes of the balancing process (detailed below in section 3.4.2.3). Table 3-1 lists some example flags that countries can use to denote the data source used.

Table 3-1: Example flags denoting source

Source	***Flag***
Official	
Semi-official	T
Imputed	I
Expert estimation	E

Country-level compilers can expand on the list of flags suggested here if they feel that more detail is necessary to properly communicate necessary information to users. In fact, a list of additional suggested flags, as well as international guidelines on observation dissemination flags, are available from the Statistical Data and Metadata eXchange (SDMX).[35] Two additional recommendations should be made, however. First, compilers should strive to use codes contained within the SDMX list, as it is both comprehensive (as in, should cover all possible data contingencies) and internationally-recognized (such that data flags would be understood by users from a different country). Second, compilers should strive to keep their data flags listing as short as possible, for reasons of clarity and data manageability. Compilers should also keep in mind that additional information about the data sources and methodologies employed can be documented in accompanying metadata (for additional information on metadata, see section 5.3.3).

3.4.2.3 Confidence and tolerance intervals

As noted above, it is crucial to the balancing process that each point estimate also be accompanied by an estimate of confidence, as signified by the tolerance interval. Estimates that come from surveys

[35] See SDMX-produced documents, "Guidelines for the Creation and Management of SDMX Cross-Domain Code Lists," and "Code List for Observation Status," available at http://sdmx.org/wp-content/uploads/SDMX_Guidelines_for_CDCL.doc, and https://sdmx.org/wp-content/uploads/CL_OBS_STATUS_v2_1.docx.

will likely be published with their measurement errors, which country-level FBS compilers should note and use in the balancing phase as the tolerance interval. For estimates that are not published with a measurement error, it is necessary for the balancing phase to assign some sort of an *a priori* assigned tolerance interval that denotes the perceived quality of the estimate—the highest quality data can be assumed to have the highest confidence and the lowest tolerance interval, while data of lower quality can be assumed to have a lower confidence and higher tolerance interval. Because quantities for different commodities in the SUA table will be standardized and aggregated, the tolerance intervals should be assigned by variable. At the same time, the sources of the data should influence the *a priori* tolerance interval value assigned to each variable, with the lowest tolerance intervals assigned to those variables for which official data are most likely. Country-level FBS compilers are encouraged to thoroughly examine their own supply chains to understand the dynamics at play, but the rationale behind likely tolerance intervals for each variable of the balance is laid out below:

Production

For at least the main commodities, most countries will be measuring production through agricultural surveys. For this reason, there should be high confidence in the production estimate. Whether or not this confidence is 100 percent or something slightly lower is up to the judgement of the FBS compilers, based on an assessment of the data collection processes under which the production estimate was derived. For example, if the compilers wish for the "official" estimate to appear in the final balance, they should assign a tolerance interval of 0%. If estimates come directly from surveys published with their own confidence intervals, compilers should feel free to use that data in this process.

Trade

As with production, most countries should have official data on imports and exports published by the relevant agency (Customs, Ministry of Trade, etc.). However, it may be the case that sizeable quantities of cross-border flows, for whatever reason, are not included in official trade data (more information on this possibility will be provided in section 3.5.2), so compilers may not have 100 percent confidence in the trade estimates, and may instead assign trade a lower degree of confidence.

Stocks

Stocks are kept to smooth consumption levels between harvests, so by their very nature they may fluctuate wildly from year to year. At the same time, most countries are not measuring stock levels, such that most estimates on stocks are already based on some sort of expert judgement. Given these factors, the confidence in most stock level and stock change estimates is likely to be lower.

Food availability

Particularly for staple foods, consumption levels are not likely to fluctuate greatly from just one year to the next, as even in the face of higher prices, households are more likely to cut spending on other goods rather than change their food consumption patterns substantially. For this reason, although food availability is not typically measured by countries, it is also likely to be fairly stable over time. Thus, although some flexibility may be needed in food availability for the purposes of balancing the supply = utilization identity, the confidence in the food estimate should be quite high—perhaps not at the levels estimated for production and trade, but higher than the confidence in the other variables of the balance sheet.

Food processing

Food processing will in most cases be dropped from the balance before the balancing process in order to avoid double-counting. As such, in most cases it will not need to be assigned a tolerance interval for the balancing process. In cases where it is not dropped, its tolerance interval should mirror that assigned to production (since food processing quantities are directly linked to the production of derived commodities through extraction rates).

Feed

Depending upon how the feed estimate is derived, it may have a larger or smaller implied tolerance interval. This is for two reasons. First of all, most countries do not measure feed use, implying that confidence in the point estimate is low to begin with. Second, although the total feed demand for a country in terms of nutrient value should be a hard number (if an accurate livestock count is available), the substitutability of feedstuffs ensures that for each individual commodity, the amount of feed might vary greatly from year to year depending upon relative pricing. For this reason, the tolerance interval of the feed estimate may be quite high for certain countries. For other countries where good data is available from feed industries and there is high confidence in data on estimated numbers of livestock, it is possible that there could be high confidence in livestock data, implying a lower tolerance interval.

Seed

Quantities of seed needed for the following year are solely a function of planted area and seeding rates.[36] Although planted area may fluctuate depending upon crop prices, the seeding rate should remain stable. For this reason, even if estimates of seed use are imputed, if there is a solid estimate of planted area in the following year, seed use estimates should be fairly rigid so as to maintain a plausible seeding rate. However, if no estimate of area is available, then seed use may have a lower confidence.

Tourist Food

Estimates of tourist food are somewhat flexible. This is because the proposed imputation methodology assumes a level of food consumption by tourists that is a rough approximation—it is not based on any measurements. As such, the confidence in this variable should likely be lower.

Industrial Use

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[36] It should be noted here that seeding rates may vary according to production system even within a country. In those cases, an average seeding rate should be used, taking into account the prevalence of the various production systems.

In most cases, the confidence in industrial use estimates will be fairly low. This is because only limited data is available on industrial uses of commodities, and most of these estimates are limited to biofuels usage. In reality, there are many more industrial uses of commodities (including starches, paints, and cosmetics), but measurements or estimates about the quantities of commodities used in these processes is very scarce. For this reason, the tolerance interval of these estimates or imputations is likely to be higher.

Loss

Despite the push for better data on loss in the context of the Sustainable Development Goals, for most countries and commodities, data on loss is very limited. In addition, the quantity of loss may not be consistent from year to year, due to crop size, constraints in storage, transportation and infrastructure constrains, weather, or dozens of other factors. For this reason, as with industrial use, confidence in these estimates is likely to be low.

Sample confidence and tolerance intervals given a priori knowledge of variables

Based on the previous considerations, an *a priori* assignment of example confidence and tolerance intervals by variable may produce a table such as Table 3-2 below. Users should keep in mind that the values in Table 3-2 should be based on a discussion of the quality of data inside the country compiling the balance sheets—they should not feel bound to use the values suggested here. However, it is advised that compilers fix at least one element in the supply = utilization identity (likely production and/or trade).

Table 3-2: Examples of tolerance intervals by variable

Variable	*Confidence*	*Tolerance interval*
Production	1.0	± 0%
Trade	1.0	± 0%
Stocks	0.75	± 25%
Food	0.90	± 10%
Food processing	1.0	± 0%
Feed	0.75	± 25%
Seed	0.90	± 10%
Tourist Food	0.75	± 25%
Industrial Use	0.75	± 25%
Loss	0.75	± 25%

3.4.3 Data search and assessment

Keeping in mind the considerations for data comparability and data quality laid out in the previous sections, the first step in compiling balance sheets is to undergo a search for all possible available data sources of the variables described in section 2.2.1. Compilers are encouraged to start by inventorying official data sources, and then reach out to commodity or supply chain experts (in both the public and private sector) for their input on alternative available data sources (suggested data sources will depend upon the variable in question, and are elaborated below in section 3.5).

Compilers should assess each data source identified for both data comparability and data quality. For all sources, compilers are encouraged to note the release date or frequency with which the data is produced, the product classification system used, the unit of the data, the reference period, and the data quality or flag. This assessment should be documented, to the extent possible, in order to ensure both transparency and institutional memory. A sample data assessment grid is provided below in Table 3-3. It should be further noted here that many of the data parameters documented in the data assessment grid will be helpful in ensuring that the underlying metadata of the final FBS product is complete. FBS compilers should be aware that as data sources may in some cases be specific to certain commodities, it may be more appropriate to either fill out a separate assessment grid for that commodity, or else to also note the relevant commodity for the data source within the general assessment grid.

Table 3-3: Sample data assessment grid

Variables	***Sources***	***Release date/ frequency***	***Classification***	***Unit***	***Reference Period***	***Quality/Flag***
Production						
Trade						
Stocks						
Food						
Food Processing						
Feed						
Seed						
Tourist Food						
Industrial Use						
Loss						
Additional Parameters						

3.5 Suggested data sources and imputation

During the course of the data inventory and assessment, compilers will need to consult a variety of sources that could potentially offer information about each of the variables in the food balance sheet. Additionally, in instances where a data source cannot be found, missing values must be imputed. The guidance on both potential data sources and suggested imputation methodologies, however, will differ based on the variable in question. For that reason, the following section explores FBS data input needs on a variable-by-variable basis.

3.5.1 Production

Data on agricultural production is one of the foundations of the food balance sheet framework. Arguably, it is so important that countries not currently collecting agricultural production data (at least for the major food crops) should consider first investing their resources in generating reliable data on production before endeavoring to compile food balance sheets.

At the same time, it is likely that even countries with highly-developed official survey methodologies may not collect production data on every single commodity, with minor crops often overlooked in annual surveys because including them may be cost-prohibitive.[37] For that reason, some suggestions on alternative data sources and imputation strategies are included also.

Before the discussion on data sources begins, one point touched on in the previous section bears repeating. For crops where harvests straddle two calendar years, compilers should assign production to whichever calendar year in which most of the crop will be consumed (for a more extensive treatment of this topic, see section 3.4.1.3).

3.5.1.1 Official data sources

The preferred source of data on agricultural production—including the production of crops, livestock, and derived goods—is survey-based official data. It is highly recommended that, at the very least, countries conduct annual production surveys for major commodities, and endeavor to measure all commodities in less frequent agricultural censuses or structural surveys. Additionally, it is recommended that official sources collect not only information on production output, but also on activity (sown area, harvested area, number of animals) and productivity (crop yield per unit of harvested area, milk yield per milking animal, meat yield per animal slaughtered, etc.) variables. This information is helpful for two main reasons. First of all, they are useful for validating production data—higher crop production, for example, results only from some combination of increased cropping area or increased yield. Therefore, checking the feasibility of growth in area and yield can serve as a very rudimentary, but accessible, check on the feasibility of the overall production estimate. The second reason for measurement of activity and productivity variables is to assist in imputation of missing data in future years or years where surveys do not take place.

Outside of surveys, administrative data may be another potential data source for certain products. The most common example of this is likely data from slaughterhouses, which may be required to keep records on the numbers of animals slaughtered and whether or not the carcasses have been

[37] However, ideally these minor products are still captured in periodic agricultural censuses or structural surveys.

inspected. Data from industrial output surveys may also be useful sources for the production of derived products, such as flour or beer.

Specific guidance on how to improve collection of official data on either crop or livestock production is beyond the scope of these Guidelines. However, the Global Strategy has produced several publications that countries may find useful in their quest to improve production data for both crops and livestock.[38]

3.5.1.2 Alternative data sources

Country-level FBS compilers can consult two additional potential data sources in their search for production data: records of private firms, and commodity organizations.

Particularly in cases where crop production is concentrated in a small area, or where production is delivered to a handful of firms for further processing, an aggregated production figure for the country as a whole can be derived from just adding up the individual purchase records of said companies. These records may be accessible through tax authorities, or through an agreement with an industry/commodity organization.

Even in cases where records from firms are not available, direct production estimates from commodity organizations could also prove useful if their members represent nearly all production. They can be a particularly helpful source for information regarding production of minor or cash crops. Some of these commodity organizations are international in scope, and publish data on a variety of countries. Examples include the International Coffee Council, the International Cotton Advisory Committee, the International Sugar Organization, and Oil World. In other cases, commodity or industry groups will be specific to only the country in question, and may even only specialize in a certain production area.

3.5.1.3 Imputation and estimation

The suggested imputation strategy for missing production data at the country level depends somewhat on the commodity for which production is to be estimated, with different approaches to imputation suggested for crops, processed products derived from crops, and livestock-derived products. Individual strategies for these three groups are laid out below:

Crop production imputation

When estimating production of crops, imputation is based upon the following identity:

$$Production\ (MT) = Yield\left(\frac{MT}{HA}\right) * Harvested\ Area\ (HA) \qquad (3\text{-}1)$$

As noted above, it is highly recommended that country-level crop production series publish estimates for not only production, but for yield and harvested area also. This is done partly as a

[38] For Guidelines on how to collect data on agriculture by including production modules in other household surveys, see, Global Strategy (2015a). For information on estimation of crop production, see Sud et al. (2016). For further information on estimation of livestock production, see Moss et al. (2016).

data validation mechanism, but also to ease crop forecasting, given that yields for most crops follow a definite positive trend over time. It should be noted here that in the agricultural survey program of many countries, data is collected on sown area, but not on harvested area. While data on harvested area is preferred for the purposes of imputing missing production data, sown area estimates can also be adapted and used for this purpose.

Luckily, as should be evident from equation (3-1), calculating any of the three unknowns (production, yield, or area) requires only an estimate of the other two terms. So for production, the suggested imputation approach is a three-step procedure;

Step 1: Measure, impute, or approximate a yield estimate.

Step 2: Measure, impute, or approximate an estimate of harvested area.

Step 3: Multiply yield and harvested area estimates together to arrive at a production estimate.

Each of these steps is detailed further below.

Step 1: Yield Estimate

Yields are sometimes measured directly by government agencies (from objective yield surveys, for example), and if such measurements have been made on a representative basis, then these can serve as an overall yield estimate. Alternatively, if production and harvested area have been measured, then yields can simply be calculated by rearranging equation (3-1) as follows:

$$Yield\ \left(\frac{MT}{HA}\right) = \frac{Production\ (MT)}{Harvested\ Area\ (HA)} \quad (3\text{-}2)$$

In the case that governments are not directly measuring yield or production, analysts should also consult any other available sources that may be collecting or estimating quantitative information on yields. For example, early warning system reports [such as the Country Briefs produced by FAO's Global Information and Early Warning System (GIEWS) group][39] may either contain information about yields or production and area (such that an estimate of crop yield could be derived).

In cases where yields are not measured, imputation using time series estimation is recommended. This approach is preferred because although crop yields in any given year can depend upon a host of factors (including temperature, rainfall, pests, diseases, and production management), over time, yields tend to follow trends. Three principles should guide this estimation process:

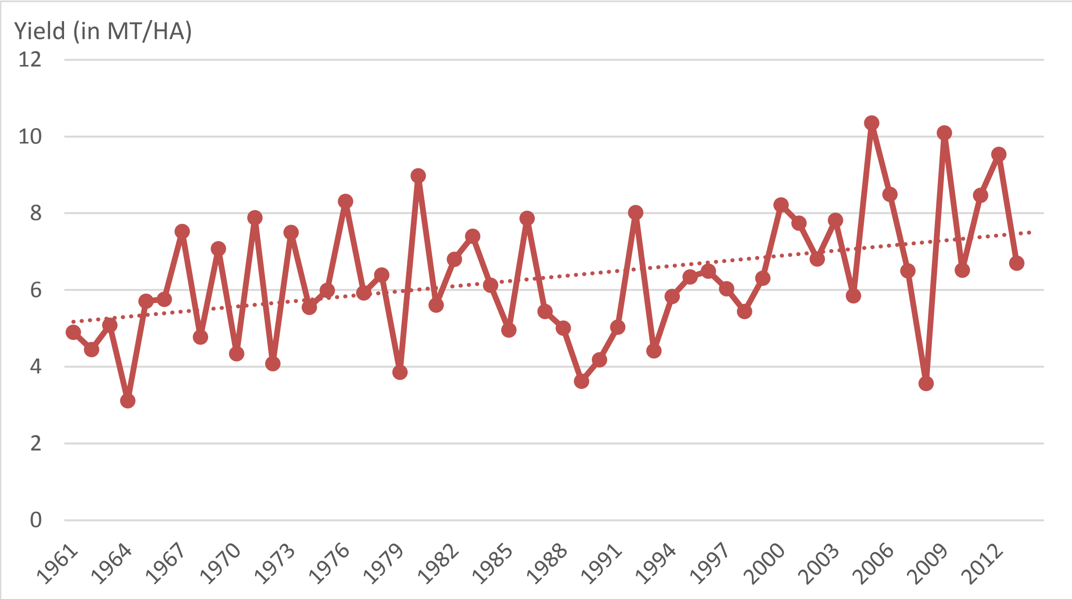
Principle 1: Understand the nature of yields for the crop being modeled

Any yield modeling exercise should be preceded by a graphing of historical yields and some general research into the typical characteristics for yields of the commodity in question. For example, many fruit and nut trees follow alternate bearing cycles, such that

[39] For more information, see the GIEWS webpage, available at: http://www.fao.org/giews/en/.

although the general trend is toward higher yields over time, a year of high yields will often be succeeded by a year of low yields. Avocado yields in the USA behave in this manner (Figure 3-1): although the linear trend of avocado yields over time (the dotted line) has been positive, the tendency of yields to fluctuate from year to year is evident. Failure to take into account these sorts of idiosyncrasies can lead to highly erroneous yield estimations.

Figure 3-1: Avocado yields in USA, 1961-2013



Source: FAOSTAT.

Principle 2: Use the appropriate functional form

The graphing of historical yield data should be followed by an analysis to determine which functional form best fits the data. Once this form is known, yields in missing years should be estimated using this type of function.

Principle 3: Include other relevant explanatory variables in the estimating regressions

As noted above, a long list of factors can influence yields for a given commodity in a given year. Nevertheless, country-level analysts should include in their estimations some of the primary variables that have been shown to have a good explanatory relationship with the final crop yield. These may include, for example, average diurnal temperature, planting date, the occurrence of natural disasters, or amount of rainfall during grain filling.[40]

Aside from following these three yield modeling principles, analysts should also take into account any relevant qualitative information on yields. For example, if it is known that a substantial pest

[40] It is likely that, for whichever crop is being considered, a simple web search will yield various scholarly articles related to yield estimation or projection that will help analysts to pinpoint exactly the explanatory factors that they should focus on.

infestation reduced output in the current year as compared to the previous year, then estimated yields should reflect this decline, even if available imputation modules fail to capture a reduction.

Once country-level analysts have measured or imputed a crop yield, then they can move to Step 2.

Step 2: Harvested Area

If an estimate of harvested area has been established from surveys, then FBS compilers can use that estimate, along with the yield estimate discussed in step 1, and proceed to step 3.

If no harvested area estimate has been derived from surveys, then country-level compilers must estimate a likely harvested area. If some sort of survey of *sown* area took place, then estimating harvested area should be straightforward, as harvested area is by definition the quantity of sown area minus any land that has not been harvested (also referred to as "abandoned" area). In this case, all that is needed to calculate a harvested area is the estimate of sown area, and some estimate of the percentage of land that was abandoned (represented by *abd*), as below in equation (3-3).

$$Harvested\ area_t = (1 - abd)Sown\ area_t \qquad (3\text{-}3)$$

It may also be the case that rather than estimating some percentage of abandoned area, countries may have some information as to the actual area of land abandoned (likely due to a particular phenomenon, such as a hurricane, flood, or pest infestation). In that case, harvested area can be estimated directly simply by subtracting the quantity of land abandoned from the quantity of area sown, as in equation (3-4) below.

$$Harvested\ area_t = Sown\ area_t - Abandoned\ area_t \qquad (3\text{-}4)$$

In cases where an abandonment rate or a quantity of abandoned area is unknown, but the sown area is known, FBS compilers can, as a last resort, use sown area to proxy for harvested area. They should note, however, that this approach will lead to overinflated production estimates, since crop yields are by definition estimated with respect to harvested area.

If sown area is not known, then FBS compilers will need to devise an alternative strategy for estimating harvested area. This could involve either first estimating sown area [and then deriving harvested area using either equation (3-3) or (3-4)], or else estimating harvested area directly. Estimating sown area first and then deriving harvested area is recommended, as sown area is more likely to be correlated to other observable data, and thus can be more easily imputed. Sown area is commonly modeled as a function of either the previous year's sown area or of farmer price expectations at time of planting (or as a combination of the two). Country-level FBS compilers are encouraged to consult the relevant literature for the commodity in question in order to formalize their strategy for estimating sown area.

If modeling sown area does not seem feasible, then the last approach that can be adopted is that of basing an area estimate on qualitative reports (as discussed above for yields). For example, early warning system reports often publish estimates of harvested or sown area—either in absolute terms, or else relative to the previous year. Such reports can then be used to estimate harvested area.

Once compilers have an estimate of harvested area (using any of the strategies elaborated above), they can proceed to Step 3.

Step 3: Derive production estimate by multiplying estimates for harvested area and yield.

With estimates of both harvested area and yield in hand, FBS compilers need only multiply the two together using equation (3-1). Compilers are reminded that, in the case of imputation or estimate of either yield or area, the quality flag assigned to the production estimate should reflect the quality of the yield and harvested area used to derive the production number.

Processed products derived from crops

In the context of the FBS, "production" of processed products is directly linked to the amount of a primary, secondary, or even tertiary good allocated to food processing (which will be covered below in section 3.5.5). As such, imputation of derived product production differs from imputation of primary product production, in that the only two pieces of information necessary for imputing values for derived goods are 1) the amount of the primary good that is being processed (that is, quantities of primary goods assigned to the *food processing* variable), and 2) the extraction rate. For most products, extraction rates will fluctuate very little over time, so assuming fixed extraction rates is a reasonable approach. But estimating the *quantity* of a given primary commodity destined for processing can be a bit more complicated, and may likely require some input from a panel of experts. In addition, if multiple derived goods stem from the same primary commodity, then analysts will need to make assumptions about what share of the processed use of the primary commodity is being diverted into production of each of the derived goods. A sample exercise along these lines is provided Box 2-1, contained in section 2.3.2.

Livestock and livestock product imputation

Imputing data for livestock, derived livestock products like meat, and live animal products (such as dairy and honey) should follow a slightly different rationale than the imputation of missing crop production data. In this process, the objective of FBS compilers should be to synchronize production of all of the various derived products using livestock commodity trees as their guide. This is done by working backward from any official data on production of a given derived commodity [by dividing by extraction rates, as in equation (2-8)] in order to impute values for higher levels of derived products. In this way, ultimately analysts can work backward to the number of functional animal units needed to maintain reasonable yields of the product in question (e.g., number of animals slaughtered in the case of meat products, or number of milking animals in the case of dairy products). In addition, compilers should be mindful of synchronizing production of co-products as outlined in commodity trees, using this synchronization to impute missing production data. For example, if official data is provided for cheese, country-level FBS compilers can use the inverse of known milk-to-cheese conversion factors to calculate a likely value of the amount of milk used to produce said cheese. Then this same amount can be used to impute a value for production of cheese co-product, whey.

For missing production data on derived processed animal products (such as meat and skins), the lynchpin of the synchronization process is an estimation of the number of animals slaughtered. Using this estimate of animals slaughtered, and applying the appropriate yield conversion factor for the product in question, estimates for production of meat, offals, fat, and hides/skins can be derived, as in equation (3-5):

$$Production\ (MT) = Yield\ \left(\frac{MT}{Animal}\right) * Animals\ Slaughtered \quad (3\text{-}5)$$

If FBS compilers know the number of animals slaughtered, then imputing production of derived goods is simply a matter of applying the appropriate yield factors. If the number of animals slaughtered is not known, but production of at least one derived product is known, then FBS compilers should start from that number and work backwards to first derive an estimate of the number of animals slaughtered, then use that number of animals to impute production of the remaining slaughtered animal products using yields applied in the previous year.

Many countries do, for example, produce an official estimate of meat production if the legal framework mandates that all meat must be inspected by a government entity. Using this estimate of meat production, FBS compilers can use the previous year's carcass weight yields (as carcass weights do not vary greatly over time)[41] to work backward to derive an estimated number of animals slaughtered, as below in equation (3-6).

$$Animals\ Slaughtered = \frac{Production\ (MT)}{Carcass\ Yield\ \left(\frac{MT}{Animal}\right)} \quad (3\text{-}6)$$

FBS compilers should note that carcass yields for various animals may be expressed in smaller units, but the overall national production estimate will likely be expressed in MT, such that some additional unit conversions may be required. For example, carcass weight yields of chickens will likely be expressed grams or decigrams. In that case, a production value can either be calculated by 1) first multiplying the carcass yield expressed in grams by the number of animals slaughtered, then converting that number from grams to MT, or 2) first converting the carcass yield from grams per animal to MT per animal, and then multiplying that value by the number of animals slaughtered.

All of these cases assume that some official data on livestock or livestock products exists and is complete. However, the reality for many countries is that while data may be available for officially-registered or slaughtered animals, a substantial portion of livestock and production of livestock-derived goods may not be registered through official channels. In these cases, FBS compilers are advised to combine official data with an estimate of non-registered animals or production of livestock-derived goods outside of official channels in order to derive a "total" figure from which the imputations described above can be carried out.

3.5.2 Trade (Imports and Exports)

[41] Compilers should note that, in cases where domestic animal carcass weights differ substantially from imported animal weights, it may be preferable to use instead a weighted average carcass yield taking these differences into account.

For a given product, data on international trade in agricultural goods includes three dimensions—quantity (typically expressed in metric tons), value (expressed either in local currency or in US$), and a unit value (that is, the quantity divided by the value). While unit values may not directly be reported in international trade data, they are easily calculated by the identity noted above, and they can be used to check the consistency of trade data across time—that is, while import quantities and import values may fluctuate greatly, unit values are more likely to remain at similar levels (or at least at the same order of magnitude) year after year.

Of all the variables involved in FBS compilation, data for the international trade variables of imports and exports are the most likely to be reported reliably by official sources (usually the national customs office). This is due to the fact that most countries mandate the collection of data on all cross-border goods transactions for tax purposes (as well as for reasons of compliance with WTO and WCO guidelines)—most commonly through customs declarations.

At the same time, particularly in trade of agricultural goods, official reported trade flows may not encompass all cross-border transactions. First of all, food aid transactions are sometimes excluded from official trade flows, yet they could potentially be a source of a significant proportion of a country's food supply. Additionally, in some countries, agricultural goods are traded outside of formal customs procedures. These trade flows, referred to here as unrecorded trade[42], can be important contributors to both household income and localized food security (Afrika and Ajumbo, 2012). Particularly given the potential contribution of unrecorded trade to food security, it is vital that, where relevant, these transactions are accounted for in a food balance sheet setting. These flows may be particularly important for the accurate estimation of livestock populations, especially for countries with large nomadic herder populations who may frequently cross national borders with their herds.

For these reasons, while official trade data is likely available in most cases, it may need to be supplemented with data from other sources in order to provide more accurate aggregate import and export estimates in a food balance sheet setting. In these cases, several additional data resources are available. An additional valuable trade data cross-checking tool is the use of mirror statistics (trading partner data).

3.5.2.1 Official data sources

As described above, most of the world's countries collect official data on both imports and exports of goods via customs declarations. Customs declarations can require the provision of a wide variety of information about a given cross-border transaction, but they must include a commodity code for the product to aid in classification (almost always an HS-based code), as well as the weight of the shipment.[43] Aggregated data from customs declarations for use in national FBS compilation can typically be accessed directly from whichever national administrative body is charged with reporting on trade data, which may be the national customs office, Ministry of Trade, or National Statistics Office. Although other international data sources exist (covered below in 3.5.2.2), using data sourced from domestic agencies will in some cases allow countries to produce more timely estimates, as this data tends to be updated and disseminated frequently.

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[42] Depending upon the source publication, various terms are applied to these trade flows, including "Informal Cross Border Trade," "informal trade," "grey trade," or "shadow trade."
[43] For more information on the types of information typically included in a customs declaration, see UNSD (2004).

Aside from customs declarations, country-level FBS compilers may wish to consult additional official administrative records in the case that potential issues with official customs data are identified. Other sources that can be consulted include shipping manifests, ship registers, port administration reports, or enterprise surveys.

In some cases, countries also produce official data estimating otherwise unrecorded trade flows. Uganda, for example, annually conducts an "Informal Cross Border Trade (ICBT)" survey to collect information about the scope of these trade flows.[44] The country's 2014 survey suggested that ICBT exports were nearly one-fifth the size of formal exports, and agricultural goods represented almost half of those unreported trade flows. Cases such as this underscore the importance of monitoring or surveying unrecorded trade flows for statistical purposes for countries where these flows are recognized as occurring. For the purposes of compiling an FBS, it is crucial to combine an estimate of unrecorded trade flows with the official trade data in order to arrive at a more realistic total trade estimate.

3.5.2.2 Alternative data sources

For FBS compilers who for some reason cannot access national customs data or for compilers who wish to cross-check the data or consult other sources, there are various options, including international trade databases that cover mostly formal trade flows, mirror data from trading partners accessed through international trade databases, resources for estimating unrecorded trade, and data sources that document food aid shipments. Each of these is described below.

International trade databases

For the majority of the world's countries, official customs data is forwarded to the UN Statistics Division, where it is checked, organized, and published in the UN's signature trade database, Comtrade.[45] Comtrade is a comprehensive database, which publishes trade statistics by year, reporting country, partner country, trade flow type (import, export, re-export), and HS code. Countries may choose to utilize this data in place of national customs data in cases where accessing that data is difficult. It should be emphasized here that the data published by Comtrade are official trade statistics, reported by national statistical authorities. As such, although data from Comtrade are not directly sourced from a national statistical agency, they can still be considered "official data" for the purposes of FBS compilation.

FAO also produces a dataset on agricultural trade that FBS compilers may find useful. This dataset is elaborated on the basis of Comtrade data, but it undergoes additional validation steps to identify outliers and, if necessary, to adjust them. FAO's dataset attempts to account for food aid and unrecorded trade flows, rendering it a more complete dataset for food balance sheet purposes. The last advantage of the FAO dataset is that it attempts to fill gaps in Comtrade data by using partner trade flows to help document trade in countries that do not report to Comtrade, or for which data has not been updated in Comtrade. As such, FAO's dataset contains imputations and estimations, thus it is not entirely an official data source.

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[44] For more information see the Bank of Uganda's ICBT survey website, available at: https://www.bou.or.ug/bou/publications_research/icbt.html.
[45] This database is publicly available, at: http://comtrade.un.org/.

"Mirror" data from trading partners

Within the Comtrade and FAO datasets, countries are encouraged to check the trade flows reported by their trading partners—referred to as "mirror" data—in instances where no official trade data is available, or as an additional validation of their own national data. This is partly due to the greater overall reliability of import data. Because countries oftentimes tax imports through tariffs, there is a tendency for import data to be more closely and accurately monitored. As most exports are not taxed, sometimes those trade flows are not adequately captured, even in official data. In those instances, it may make sense for compilers to consult partner data and, if necessary, further investigate the reason behind the discrepancy, or even override their official trade figures. For countries that do not report trade data, consulting trade partner mirror data is necessary to formulate a detailed picture of a country's agricultural trading pattern.

Unrecorded trade resources

In countries where unrecorded trade is reported to be substantial, compilers should at least attempt to quantify those values. Some data sources are available for certain regions of the world that could be helpful in this process. For example, the FEWS NET network produces periodic cross-border trade reports for both East and Southern Africa.[46] These reports typically estimate quantities of cross-border trade, by commodity, and they also document the underlying dynamics driving changes in these trade flows.

The Permanent Interstates Committee for Drought Control in the Sahel (known by its French acronym, CILSS, for Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel) also collects data on unrecorded trade flows between eight West African countries for both major cereal grains and livestock.[47] Compilers from countries in that region should consult the CILSS reports on intra-regional agricultural trade in order to ensure the completeness of export and import data for food balance sheet purposes.

Food aid data

For some countries, food aid shipments do not show up in commercial shipment data, which can lead to a drastic underestimation of total imports, with consequences for food availability. If country-level compilers suspect that food aid shipments are excluded from trade data, efforts should be made to add food aid quantities to commercial quantities to arrive at an estimate of total trade for FBS compilation purposes.

The World Food Programme (WFP) is the UN Agency that oversees most deliveries of food aid. At this writing, however, WFP is adjusting the way that it reports food aid shipments. Through 2016, WFP published data on food aid shipments (through calendar year 2014) on their INTERFAIS website.[48] Beginning in 2017, this platform will be sunsetted, and WFP will instead report their food aid shipments through the International Aid Transparency Initiative (IATI).[49] In

[46] These reports can be accessed thru FEWS NET's Markets & Trade portal, at: https://www.fews.net/sectors/markets-trade.
[47] These reports are posted on the CILSS website, available at: http://www.cilss.bf/spip.php?rubrique59.
[48] The INTERFAIS data is available through this portal: http://www.wfp.org/fais/.
[49] The website of IATI is available at: http://www.aidtransparency.net/.

addition, FAO's GIEWS team will begin to collect and publish data on non-WFP food aid shipments.

Country-level FBS compilers should consult these resources for information on food aid flows. Compilers should be aware, however, that there has been a dramatic shift in the way that food aid is delivered to countries over the past decade—where donor countries previously gave physical quantities of food, now they are much more likely to donate money, either for local procurement of food aid, or to assist the hungry in purchasing food directly from the market. For this reason, the actual quantity of physical food deliveries has declined over the years. As an example, the quantity of wheat food aid distributed by WFP has declined from more than 7.8 million MT in 1988 to just under 1 million MT in 2012 (although this decline was likely the result of a combination of factors and not solely due to a shift to more cash-based food aid) (WFP, 2017).

3.5.2.3 Imputation and estimation

No methodology is suggested for imputation and estimation of trade data at the country level, as various datasets already exist that should cover the trade data needs of most countries. However, as described above, country-level compilers may wish to adjust official trade data based on informal trade data or on mirror data from trading partners. These options are both detailed in the previous section.

3.5.3 Stocks/stock changes

Systematic long-term holding of stocks is typically limited to a handful of products that are non-perishable and most likely important to domestic food security needs—mostly grains, but also sugar, pulses, and some oilseeds. At the same time, countries may hold short-term stocks from one marketing year to the next of various other products, like horticultural goods (apples or potatoes), processed horticultural products (frozen concentrated orange juice or canned tomatoes), or processed dairy products (butter or cheese).

Given the effect that stock levels can have on food prices and their strategic use as a safeguard for domestic food security, accurate measurement of total stockholdings among all actors (at least for the primary food commodities) should be a policy priority for countries. However, data coverage of total stocks estimates is, at present, extremely limited. This is partially due to the complexity of measuring stock levels, as they can be held anywhere along the supply chain. For this reason, in order to accurately collect data on or estimate stock levels, it is strongly recommended that country FBS compilers first assess the stock situation in their country by speaking with industry experts and relevant government officials to determine which commodities are being stocked and how those stocks are organized (including which stakeholders are keeping those stocks, and the size of stockholdings among the different stakeholders). There are some efforts underway to improve data collection on stock levels, but many country-level FBS compilers may find that stock changes will need to be imputed or estimated.

3.5.3.1 Official data sources

Official government agricultural surveys are the preferred mechanism through which to collect data on stock levels, as surveys can target the supply chain actors most likely to hold stocks—farm surveys can produce estimates of on-farm stocks, while surveys of processors, manufacturers, exporters, or distributors can target stockholding elsewhere in the supply chain. Governments themselves may also be large stockholders of certain food commodities. If countries are able to collect data on stocks held at the farm level, in the private sector, and in the public sector, then an overall picture of the country's stocks situation should be mostly complete and provide a solid estimate for FBS compilation purposes.

Because collection of stocks data is so critical to removing sources of error from the balance sheet, it is highly recommended that countries make explicit efforts to measure stock levels of major commodities rather than rely on an imputation or estimation approach.[50] Two particular efforts are suggested. The first of these is the adding of a stocks module to periodic agricultural production surveys. This action would greatly improve the availability of data for on-farm stock levels for primary food commodities. The second action is the reporting of government-held stock levels. Particularly in countries where governments hold large inventories of important food staples, the absence of administrative data on stock levels will severely limit the usefulness of compiling food balance sheets to assess overall food supply and demand.

As mentioned above, there are several global efforts underway to improve measurement of stock levels within a general push for improved information related to agricultural statistics. In fact, the Global Strategy stresses the importance of information on stocks for developing countries by including this variable in the minimum set of core data that should be measured and disseminated annually (FAO et al., 2012). The most prominent efforts have been led by the global Agricultural Market Information System (AMIS). Subsequent to an "Expert Meeting on Stocks Measurement" in November of 2014, AMIS has recently drafted "Guidelines for Designing and Implementing Grain Stock Surveys," (forthcoming), and is also planning various other activities designed to assist countries in improving their stocks measurement.[51] In that same vein, in November 2016, FAO and the Indian Ministry of Agriculture & Farmers Welfare (MAFW) held a joint seminar on "Approaches and Methodologies for Private Food Grain Stock Measurement," and all the presentations on the various approaches are available online as a resource to country-level FBS compilers.[52]

3.5.3.2 Alternative data sources

Outside of official sources, data on stocks is likely to be limited to only one aspect of the supply chain (processors, for example), and thus provide an incomplete picture of a country's total stock levels. For this reason, countries are encouraged to develop strategies to survey overall stock levels in an official capacity rather than rely on incomplete estimations from one segment of the supply chain. For some supply chains, however, reports of stock levels from processors or industry could account for the majority of stockholdings, and thus be invaluable to estimating total stock levels.

[50] In fact, this is the recommendation of AMIS for AMIS member countries. In addition, they recommend that both on-farm stocks and stocks held by commercial actors both be surveyed and combined to produce an overall stocks estimate. For more information, see AMIS (2015).
[51] For more information on the content of the discussions at the "Expert Meeting on Stocks Measurement," see AMIS (2015). AMIS' "Guidelines for Designing and Implementing Grain Stock Surveys" will be published sometime in 2017. For more details on the planned program of work related to stocks measurement, see AMIS (2016).
[52] Related documents are available at: http://www.fao.org/asiapacific/events/detail-events/en/c/1363/.

Compilers may also wish to consult the AMIS database, which estimates closing stock levels for maize, wheat, rice, and soybeans for more than 20 of the world's largest producers and consumers of those commodities.[53] Similarly, estimates on global sugar stocks can be accessed from F.O. Licht, and stocks estimates for numerous oils and fats can be sourced from Oil World.[54]

3.5.3.3 Imputation and estimation

After all possible data collection opportunities have been exhausted, country FBS compilers can use a few different approaches to impute or estimate stock changes, subject to some cumulative constraint on stock levels. The approaches may vary depending upon the commodity in question.

Suggested Approach

From a purely mathematical point of view based on the supply = utilization identity, stocks represent the mismatch between supply and utilization in a given year. Because most domestic utilizations tend to change little from year to year, changes in stock positions tend to be correlated with changes in production net of trade (that is, production plus imports, minus exports). As such, changes in stocks can be modeled as a function of changes in production net of trade, as follows.

$$\Delta Stocks_t = f\ (\Delta ProdNT_t) + \varepsilon_t \tag{3-7}$$

Where:
$\Delta Stocks_t$ is equivalent to $Closing\ Stocks_t - Closing\ Stocks_{t-1}$,
$\Delta ProdNT_t$ is equivalent to $[Production + Imports - Exports]_t - [Production + Imports - Exports]_{t-1}$, and
ε_t is an error term.

FBS compilers can estimate this relationship using regression analysis and choose the functional form most appropriate for their situations. Compilers may wish to add additional variables in their regressions, but the basic approach should remain the same. It should be emphasized here that imputation of stock changes through this suggested approach relies on countries having historically measured stock levels for the commodity in question.[55]

At the same time, estimates of stock changes derived from regressions must be checked against a constraint for cumulative stock levels. That is, a negative stock change in any given year may not exceed the previous level of stocks, as violating this constraint would mean that countries are using more stocks than they possess.

The last concept to keep in mind when modelling stock changes is that over several successive years, cumulative stock changes should sum to approximately zero. To see why this should be

[53] See the AMIS database, available at: http://statistics.amis-outlook.org/data/index.html#HOME.
[54] Both the Licht's data and the Oil World data are behind a paywall. Further information is available on their respective websites—For Licht's, see: https://www.agra-net.com/agra/international-sugar-and-sweetener-report/; For Oil World, see: https://www.oilworld.biz/t/publications/data-base.
[55] We also note here that this approach does not consider prices or price changes, which have been shown to be correlated to stocks [see, for example, the elaboration of the "Supply of Storage" model in Bobenrieth et al. (2004) and a follow-up analysis on the relationship between prices and stocks-to-use ratios in Bobenrieth et al. (2013)]. In fact, USDA has in the past utilized the relationship between prices and the stocks-to-use ratio to inform forecasts of domestic season average farm prices—see, for example, Westcott and Hoffman (1999). Knowledge of this relationship could assist countries in estimating stock changes, or could help to validate estimates derived through the approach proposed above.

the case, consider the following two scenarios: Country A adds to stocks every year, while Country B takes away from stocks every year. In the case of Country A, their constant accumulation of stocks has two primary problems. First, within every country, there are physical limits in storage infrastructure that by definition indicates that a country cannot stock a commodity every year. Second, the large amount of product held in stocks would eventually be the dominant aspect of a country's domestic supply, likely depressing prices to the point that further incentive to produce more of the good would be destroyed. Thus, at some point, Country A will have to remove some supply of the good from stocks. In the case of Country B, the limits are much more evident, in line with the constraint outlined above: at some point, there will be no more of the good remaining in stocks available for removal. This illustration should help country FBS compilers to recognize that, over a given period of time, cumulative changes to stocks should sum to zero.

Alternative approach

In the absence of historical data on stock levels for grains, pulses, sugar, and oilseeds, compilers can preliminarily use stocks to " balance" the supply and demand equation, but this approach should only be utilized in instances where there is some measured data used to derive estimates for food and any other relevant utilizations. Otherwise, compilers are dealing with an equation with two unknowns, and error cannot properly be accounted for. Even in this case, compilers must check cumulative changes against a running estimate of stock levels to ensure that estimated changes are feasible.

For some perishable products, stock changes can be used to smooth supply fluctuations from year-to-year. In these cases, compilers should be aware that stocks accumulated in one year should in most cases be entirely or nearly entirely used in the following year. Compilers should also consider adjusting loss to account for any stocks not allocated to some other utilization in the following year. However, before this approach is followed, compilers should have a solid understanding of the supply chain for the respective product—in particular, whether or not it is feasible to hold stocks of that good through the following year, and if so, what quantity of stocks is feasible.

3.5.4 Food availability

Recall from section 2.2.1, "food availability" as defined in the FBS setting refers to quantities of food available for human consumption at the retail level by the country's resident population. This resident population should generally include refugees and long-term guest workers, but not tourists or temporary visitors. Food availability also includes any loss or waste at the retail or consumer level. For this reason, total food availability estimates derived from the FBS are likely to be higher than actual average food consumption.

Directly measured data on food availability (as defined in the FBS setting) may be difficult to obtain. However, FBS compilers can derive estimates of food availability by making certain adjustments to other existing datasets measuring food production or consumption. The key to this process is understanding exactly how the measured quantities differ from FBS definitions, and ensuring that each one of these differences is accounted for in the adjustment process.

While adjusting certain underlying data to make it consistent with the FBS food availability definition is the preferred course of action, some countries may instead choose to impute or estimate food use values. This process is facilitated by the fact that food availability will likely vary little from year to year—particularly for staple foods that comprise the bulk of consumer diets—since countries are much more likely to see changes in trade or stock levels in order to maintain consumption of staple goods at fairly consistent levels.

3.5.4.1 Official data sources

Two primary types of official data sources may provide information useful to the estimation of a country's food availability: industrial output surveys and household consumption or expenditure surveys. Both of these sources include certain caveats, however, that compilers should take note of when assessing the value of such data for FBS purposes.

Industrial output surveys

The first potential source of data is industrial output surveys from food processors, including flour mills, oilseed crushers, dairy processors, or breweries. These data are useful for food estimates because they represent so-called "bottleneck" industries, through which all quantities of the primary commodity that will be used as food must first pass before they become edible. This phenomenon can be illustrated by the wheat industry. For many countries, wheat in its primary form is mostly fed to livestock, and for the bulk of the quantity of wheat consumed by people, it must undergo a transformation to become wheat flour before it is consumed (note that this may not be the case in all countries). In addition, wheat flour is not consumed by animals. Therefore, all production of flour (after accounting for net trade) is likely to be consumed as food.

While data from industrial output surveys can be useful for deriving food use estimates, FBS compilers should keep the following in mind when using this data:

- Data needs to represent a large proportion of total production. For this reason, these sources are only useful in countries where most processed food production occurs at the industrial level and not at the farm or artisanal level. As such, they are likely to be most applicable for either developed countries, or for developing countries with more industrialized food processing sectors and only very limited artisanal manufacturing. This point bears repeating—in countries where home processing is common, using industrial output surveys to estimate production of derived goods will result in an underestimation of the production quantity for the derived good in question.

- These data sources will only be available to facilitate estimation of foods that are processed. This leaves out several commodity segments—principally fresh fruits and vegetables.

- Estimates of industrial output for food manufacturers may in some cases only be available in value terms. Quantities may be determined by dividing these values by current prices.

- Output data for food processors are technically production quantities for those SUA-level items. Therefore, in order to use this data to arrive at an estimate of food availability at the SUA level, other uses (imports, exports, stock changes, tourist food) must first be netted out.

These observations aside, the advantages of using manufacturing output is that these data will cover processing use for all consumption occurring within a country, including food away from home and institutional consumption (including schools, hospitals, jails, or military installations).

Household surveys

The second source of useful data on food availability is household surveys. While such surveys do provide a detailed portrait of consumption at the household level, food consumed outside the home may not be fully captured. As such, household surveys can, in most cases, be considered to provide a conceptual "lower bound" for food availability. Using consumption figures derived solely from household surveys will likely underestimate total food availability within a country, and do so by potentially large margins in countries where a large portion of calories are consumed away from home, and are therefore not accounted for in the survey. At the same time, the trends in consumption evident in household surveys should also manifest themselves in overall FBS food availability levels. In fact, previous work has found that calorie estimates can vary widely between household surveys and FBS, but shares of individual food groups in overall consumption (in the case of household surveys) or availability (in the case of FBS) tend to remain consistent.[56] They may therefore prove very useful in estimating or imputing food availability, provided that FBS compilers take note of, and adjust for, the other limitations of household surveys. These may include:

- Data are typically collected only for a brief period of time, but strictly annualizing the data may be problematic for countries where consumption varies between seasons. Care should be taken to ensure that seasonality is accounted for where relevant.
- Data may be collected only infrequently every four or five years, such that quantities may need to be adjusted for subsequent years in order to account for changes in income or population, for example.
- Surveys may miss some underrepresented subgroups, thus biasing consumption estimates when extrapolated to the total population.
- Household surveys will entirely miss consumption occurring schools, prisons, hospitals, and military installations.
- Although it is increasingly less common, household surveys sometimes collect data only on expenditures and not quantities. In these cases, expenditures would need to be converted to quantities using consumer prices.

[56] For more information on this finding, as well as a methodology reconciling FBS and household estimates, see Grünberger (2014).

- Surveys will not include any accounting for food waste at the retail level, and may not include food waste at the household level either, potentially underestimating total food availability.

Keeping these caveats in mind, food consumption estimates from household surveys can serve as a benchmark for estimations of FBS food availability, and can even in some cases be scaled up to better fit the FBS definition.

3.5.4.2 Alternative data sources

Even if data is collected by other actors outside of official surveys, the same two sources mentioned above—food processor statistics and household surveys—provide the best snapshots of overall data on food use within a country. At the same time, additional scrutiny may be necessary if these data are collected outside of official channels.

For food processor statistics, FBS compilers may wish to either consult industry groups, processor associations, or even a handful of firms (provided that they collectively account for a large share of the total market) to assess the availability of data at the first-line processor level. In each of these cases, compilers should note the representativeness of the data, and make adjustments as necessary. For example, if a wheat flour millers' association represents approximately 80 percent of the total market, then data on output from the association could be used to derive a total production of flour used for food simply by dividing by 0.8.

For household surveys, compilers should consider all of the caveats outlined above, paying additional attention to the representativeness of the survey.

3.5.4.3 Imputation and estimation

In the absence of data on food availability from the sources described above, food availability can be imputed. Two possible approaches are outlined below.

Suggested Approach

Recall from above that per capita food availability will likely fluctuate little from year to year, as actors within countries use trade or stocks to smooth consumption. The basic approach to imputing food use relies on this assumption, modeling food availability in the current year based on availability levels in the previous year, but by making adjustments for changes in income and the overall trend in consumption. Imputation of food availability should also account for changes in population—even if each person in a country eats the same quantity of a certain food product from year to year, adding additional people to a country's population (assuming that dietary patterns remain unchanged) will necessarily increase the amount of that product that is available for consumption as food.

The foundational linear equation for food use, using only population, trend, and food use in the previous period, can then be defined as follows for a given commodity in a given country:

$$Food_t = \frac{Population_t}{Population_{t-1}} * Food_{t-1} * (1 + \phi) \quad (3\text{-}8)$$

where food availability in the current period t ($Food_t$) is estimated as a function of the change in population (expressed here as the ratio of population in the current period to population in the previous period, or $\frac{Population_t}{Population_{t-1}}$[57]), multiplied by food availability in the previous period ($Food_{t-1}$), multiplied by 1 plus the historical trend (e.g., the growth rate) in food consumption (ϕ). In this specification, ϕ should be estimated from a regression on the historical food availability data series.

The basic specification outlined in (3-8) provides a good foundation for a basic estimate of food availability. However, most country-level FBS compilers will have access to additional information that should provide a better estimate of food availability. Specifically, country-level compilers can consider introducing both income (in the absence of data on income, this may be proxied by either expenditure data sourced from national accounts, or GDP, depending upon data availability and the preferences of the country)[58] and product-specific income elasticities of demand[59] into the equation. In doing so, the specification will depend upon how income elasticities for the product in question have been estimated. We include here the semi-log specification (indicated for income elasticities that have been estimated using an underlying semi-log functional form), as it is very similar to the linear specification, with the only addition being the income elasticity ϵ for the commodity in question, multiplied by the log of the change in the income proxy (in this example, the ratio of household consumption expenditure in the current period to household consumption expenditure in the previous period, or $\frac{\text{Household consumption expenditure}_t}{\text{Household consumption expenditure}_{t-1}}$)[60] in the additive term at the end of the equation, as below in equation (3-9).

$$Food_t = \frac{Population_t}{Population_{t-1}} * Food_{t-1} * \left[1 + \epsilon \log\left(\frac{Household\ consumption\ expenditure_t}{Household\ consumption\ expenditure_{t-1}}\right) + \phi\right] \qquad (3\text{-}9)$$

Prior to the specification of a model using income elasticities, however, FBS compilers must first identify appropriate elasticities for each of the food products or food product groups. These are likely to have been estimated by academics and/or used as inputs in computable general equilibrium models. If no domestically-recommended database or source data can be identified, then compilers can consult the database of country-specific income elasticities for food categories produced by USDA in 2005 as a next-best option.[61]

[57] This expression is also equal to one plus the percent change in population from period *t-1* to period *t*.
[58] There are a multitude of potential proxies for this exercise, but a few suggestions include either final consumption expenditure, household consumption expenditure, or gross domestic product (GDP). All of these data are published by UNSD in their National Accounts datasets, available as either "National Accounts Estimates of Main Aggregates" or "National Accounts Official Country Data." The three referenced categories can be found under "GDP by Type of Expenditure" at both current and constant prices, for both datasets. This data is publicly available at: http://data.un.org/Explorer.aspx?d=SNAAM.
[59] Income elasticities of demand measure the responsiveness of demand for a certain good to a change in income. Mathematically, this can be expressed as $income\ elasticity\ of\ demand = \frac{\%\Delta\ in\ demand}{\%\Delta\ in\ income}$. For example, an income elasticity of demand of 0.1 for a given good indicates that for every 10 percent increase in income, demand for the product rises by 1 percent. Nearly all food products are normal goods—that is, an increase in income is associated with an increase in demand for the good.
[60] This term is equal to 1 plus the percent change in household consumption expenditure from period *t-1* to period *t*.
[61] This database is publicly available, at: http://www.ers.usda.gov/data-products/international-food-consumption-patterns.aspx.

Alternative Approach

For products where food use is the sole or the overwhelming utilization, countries can employ a balancer approach (similar to that described above for wheat flour), where food availability is calculated as the balance of production minus net trade (and any other small utilization elements). Because this approach will result in food use accumulating all of the error from the other utilization elements, this approach is most appropriate for products that have no or few other utilizations…principally items that cannot be stocked for extended periods of time and are not used for feed, like meat, eggs, and certain fruits and vegetables or dairy products.

It should be noted, however, that in the final validation and balancing process, food availability estimated using either approach may be adjusted.

3.5.5 Food Processing

Food processing refers to quantities of a commodity that enter some manufacturing process for the production of a derived food product. As noted in the "Production" section, food processing quantities are linked to the production of derived commodities through extraction rates. That is, food processing is unique in that it can either be directly measured, or can be calculated by applying the extraction rate to quantities of production of derived commodities. Thus, if data on either production of a processed commodity *or* input into a transformation process is present, calculating the other quantity can be carried out with ease.

3.5.5.1 Official data sources

Two official data sources on food processing should be noted. The first are agricultural production surveys. For some commodities (such as fruits or milk), production surveys may include questions on whether or not the product is destined for the fresh market or else was sold to be further processed. Quantities reported as destined for further processing are then, by definition, food processing quantities.

Industrial output surveys are another potential data source for food processing data, albeit indirectly— if production of derived goods is reported in an industrial output survey, then compilers need only divide by the extraction rate in order to calculate the primary commodity equivalent used as input for that particular transformation process. As was noted in the section on food availability, these official data sources are only useful if a majority of processing is covered by industrial output surveys. In instances where home processing is common, this data should be combined with an estimate of total production of the derived product at the household level to arrive at an estimate of total production of the derived good, from which a food processing quantity can be imputed.

3.5.5.2 Alternative data sources

Where official data is not available, data from commodity organizations, manufacturer's associations, or even specific food processing facilities may also be useful in the calculation of food processing quantities. In such instances, however, FBS compilers should make some effort to take into account the representativeness of said data. For example, if members of a hypothetical "Orange Juice Producer's Association" are thought to cover 90 percent of all production, then orange juice production data from that association can be utilized and scaled up to arrive at an estimate of the country's total orange juice production.

3.5.5.3 Imputation and estimation

Given that estimated quantities destined for food processing are linked to production quantities of derived commodities through extraction rates, the imputation of food processing can be fairly simple in cases where data on production of derived goods exists. As was described in section 2.3.1 on commodity trees, this calculation can be illustrated by equation (2-9).

$$Primary\ commodity\ equivalent = \frac{Quantity\ of\ derived\ product}{Extraction\ rate} \quad (2\text{-}9)$$

It should be emphasized here that "food processing" quantities must cover the inputs of all derived products. As such, the application of the above equation will only result in the total quantity of food processing if only a single derived product stems from the primary good. Of course, the equation can be applied multiple times, and the values of the primary commodity equivalents can be added together to derive the overall quantity of the primary good that entered all transformation processes.

If no data on derived commodity production is available, then it is recommended that total quantities destined to food processing be estimated in a panel of experts. This panel should also determine the share of the food processing quantity that is destined to different transformation processes.

In certain particular cases, food processing can also be used as a balancing item at the SUA level. Recalling the olive example from Box 2-1, all olives are processed before they are consumed. As such, after accounting for net trade, loss, and any other utilization, all remaining olives can be assumed to be destined for food processing.

3.5.6 Feed

One of the more dramatic shifts in the global food system over the past several decades is the increasing dietary demand for animal products (meat and dairy) as incomes rise in developing countries. With rising numbers of livestock globally, demand for animal feed has also risen, and now accounts for a large proportion of global production of some crops that are also used for food (such as maize and soy). In addition, feed can be obtained from a variety of sources—including own production, feed compounders, or even common pasture resources—depending upon relative prices and (to some extent) the intensity of a given country's livestock production system. At the same time, the composition of livestock rations can also shift depending upon changes in these relative prices of feed products, such that for an individual cereal grain, the quantities allocated to feed could fluctuate from year to year. However, aggregate nutrient availability from all feed sources should remain relatively stable on a per livestock unit basis. These trends may be evident in both official and unofficial data sources, and any developed imputation approach should also take this into account.

In order to improve the accuracy of feed estimations, FBS compilers should first research the characteristics of livestock rearing in their country. Both official data collection approaches and imputation strategies should take into account the structure of livestock production systems in order to more accurately estimate feed needs.

3.5.6.1 Official data sources

Official data collection efforts on feed are subject to a similar limitation as stock data, in that feed can be sourced from a variety of actors, so arriving at an accurate picture of aggregate feed production can require various types of surveys—questions can be added to farm-level surveys about own production reserved for feed, feed compounders can be surveyed as to their output, and pasture resources can be estimated using a variety of methods. If feed compounders are not surveyed, it may also be possible to derive an estimate of their output by consulting administrative records. If costs are an issue, then ad-hoc surveys on feed use could be utilized to measure feed demand periodically, which could help to parametrize a country-specific module of feed demand and utilization.

However, it is important that this official data on feed production be cross-checked against actual livestock feed demands, in terms of both total energy and total protein requirements.

3.5.6.2 Alternative data sources

If official data is incomplete or not available, some unofficial data sources may also exist to help countries estimate feed use for certain commodities. First, it is likely that commodity interest groups would either have some measurement or estimate of the quantity or proportion of their particular commodity that is being used as animal feed. At the same time, livestock associations may publish data on feed usage, or may be able to at least provide some indication as to the composition of feed rations for certain animal groups. Regardless of whether or not these groups publish data on feed use, it is advised that FBS compilers consult these groups to gain a better understanding of the feed market in order to better inform their balance sheets.

Extension workers could also be consulted to glean information about herd sizes, most commonly-utilized feedstuffs, and local animal production systems. While this information may be an approximation, it could still be useful for estimating overall feed use, and feed use of a given individual commodity.

3.5.6.3 Imputation and estimation

Imputation of missing feed data can pose a challenge to country-level FBS compilers, as feed sources tend to be substitutable in animal feed rations, and overall feed demand will shift based on livestock populations and productivity intensity levels. Although different actors have used several approaches to estimating feed use for individual commodities[62], the general approach suggested here is based on the reconciliation of total feed demand and available feed supply. Three basic steps should be followed in this process:

<u>Step 1: Understanding and estimating total feed demand</u>

[62] For a more extensive treatment of this topic, see AMIS (2014).

Total feed demand is—at its most basic level—merely a function of the total number of animals and the nutritional needs of those animals, both in terms of total energy and protein. With respect to energy needs, total required feed demand, *FD*, is merely the product of the number of animals belonging to species i, N_i, multiplied by the amount of energy required per animal for that species, e_i, summed across all species, i, raised in the country, as in equation (3-10) below (total protein demand could be estimated using the same equation, but substituting per animal protein requirement, p, for the energy requirement, e).

$$FD = \sum_i N_i * e_i \tag{3-10}$$

Of course, the amount of energy required per animal can vary widely even within species, depending upon both the characteristics of the animal (i.e., a lactating dairy cow's energy needs are much greater than a yearling calf's energy needs) *and* the type of the production system in which the animal is raised, such as grassland-based systems versus more intensive industrialized systems.

It is important to note here that food balance sheets themselves cover only non-forage commodities, so this imputation method estimates feed demand only for non-forage commodities (in fact, it is redundant to attempt to estimate feed demand for forage, as feed is by definition the sole utilization of forage). To underscore this point, consider that livestock raised in pastoralist production systems are almost universally fed a diet solely of forage, such that their feed needs would be excluded from food balance sheets.

At the same time, the supply of forage crops are necessary for the calculation of total feed supply under this method. As such, countries are encouraged to compile data on production of forage crops (in addition to production of non-forage crops) to ensure that total feed supplies from all sources are adequately measured.

Taking all these factors into consideration, the following suggestions will assist country-level FBS compilers in more accurately estimating total feed demand:

- Understand the different livestock production systems in practice in the country for each species, including industrial, grassland-based, mixed, or backyard

- With the assistance of farm surveys and censuses, attempt to estimate the number of animals for each animal species raised in the country (including farmed fish and poultry), and the number of animals raised under each identified production system. These may include counts of animals raised under nomadic or transhumant systems, although the feed demand for such animals is typically satisfied by forage and not by grain crops and crop derivatives

- Determine the "average" animal's feed requirements for each production system

- If data on the number of animals raised under different production systems is of good quality, consider estimating the feed needs of animals raised under separate production systems as if they were a different species—for example, estimate feed needs of backyard chickens separate from industrial broiler production—in order to ensure as accurate of an estimate of total feed demand as possible

- Sum the feed needs of all animal species, both in terms of energy and protein

Once an estimate of total feed demand has been reached, FBS analysts can move on to accounting for the supply side.

Step 2: Understanding feed supply

Understanding feed supply begins with an inventory of all of the products that are potentially used for feed in the country. This should be accompanied by an analysis or ranking of which commodities are most likely to be used for feed demand. Analysts should keep in mind the fact that many byproducts from food processing—such as bran or fruit pulp—can be assumed to be utilized exclusively as feed in the FBS setting. In addition, as mentioned above, any production of forage can be assumed to be used for feed.

Once all the commodities used as feed have been identified (potentially including forage, cereals, root crops, and processing byproducts, to name a few), their dietary values per unit should be recorded. These values are publicly available for nearly 1,400 feed products via the Feedipedia online resource library.[63]

After all commodities used as feed have been identified, the work of allocating supplies to match with the feed demand calculated in Step 1 can begin. First, any official data on feed use should be recorded appropriately, converted to their total energy/protein equivalents (by multiplying quantities reported in MT by their unit dietary values), and subtracted from the total feed demand estimated in Step 1. After official feed use data has been accounted for, residual use (that is, production net of trade) of commodities only used for feed (including forages, bran, and pulps) should be considered. Again, these volumes should be converted to energy/protein equivalents and subtracted from the remaining total feed demand.

Step 3: Allocating feed supply

The final step is to allocate the remaining feed demand to available commodities. The recommended approach of doing so is to assemble a technical working group to discuss the most likely feed commodities, and distribute feed demand amongst them accordingly. Alternatively, FBS compilers can use whatever information is gathered in the initial feed inventory at the beginning of Step 2, and allocate feed demand accordingly based on the ranking of which commodities are most likely to be used as feed. As an additional option, analysts can consult the available literature on feed demand in their country for assistance in estimating feed utilization. It should be emphasized, however, that regardless of how estimates of feed demand are derived, they should be validated by the technical working group once FBS have been compiled for all commodities.

[63] This database is a collaboration between INRA, CIRAD, AFZ, and FAO, and can be accessed at: http://www.feedipedia.org/.

3.5.7 Seed

Although official estimates for seed may not exist in all countries, for any country with reliable crop area estimates, the process of imputing missing values is relatively straightforward—seed use is merely the product of an average seeding rate (the amount of seed needed for a given sown area) and the sown area in the following year (since seed use in year *t* is actually just set aside in year *t* to use for sowing in year *t+1*). For most crops, the seeding rate does not vary substantially from year to year within a given country. However, more gradual changes in the seeding rate could be expected due to the adoption of new technologies, different planting methods, or even in instances where production shifts to new areas within a country.

After production and trade, seed estimates are the balance sheet variable for which official data is most common—likely due to the aforementioned ease of imputing missing values.

3.5.7.1 Official data sources

Most official measurements of seed use data are sourced from agricultural surveys. Most surveys will include questions on both purchases of improved seed and quantities of own reserved seed, but in the case that the survey excludes purchases of improved seed, it may be possible to access the sales records of commercial seed companies in order to obtain a full estimate of total seed use. Trade data may also give some indications about seed quantities if most seed is imported, as seed typically have separate HS codes.

3.5.7.2 Alternative data sources

If an estimate of total seed use is not available and a historical seeding rate cannot be calculated from the data, compilers should also investigate the possibility of whether or not there is available data regarding only seeding rates. Information on either optimal or effective seeding rates may be available from a variety of sources. First, compilers can contact commercial seed companies to inquire about recommended seeding rates for major commodities for the varieties most commonly sold in their country. Additionally, agricultural research institutions and/or extension specialists may be able to provide some estimates as to common seeding rates in certain production regions. And in cases where governments have programs providing subsidized seed to growers, government administrative records will likely contain information on average seeding rates.

Some information on seeding rates for various commodities can also be found in the publication *Technical Conversion Factors for Agricultural Commodities*.[64] Compilers are advised that this publication is not recent, however, such that the published average rates may not reflect either current production systems or technologies.

Regardless of the source, if the typical seed rate is known, then imputing total seed use is a simple calculation, according to the methodology described below in 3.5.7.2.

3.5.7.3 Imputation and estimation

[64] This document is available here: http://www.fao.org/fileadmin/templates/ess/documents/methodology/tcf.pdf.

As stated above, seed use quantities in the FBS context represent the amount of seed set aside in the current year that will be used to produce a crop in the following year. As such, seed use in a given year *t* are a function of a seeding rate and a sown area in the following year, *t+1*, as expressed in the following identity:

$$Seed\ use\ (MT)_t = Seeding\ rate\ \left(\frac{MT}{HA}\right) * Sown\ area\ (HA)_{t+1} \quad (3\text{-}11)$$

Given this identity, the process of deriving an imputed value for seed quantity is as follows:

Step 1: Calculate/estimate a seeding rate.

Step 2: If missing, impute a value for sown area in the following year.

Step 3: Multiply the two values together for an estimate of total seed use.

Further details of each of these steps are laid out below:

Step 1: Seeding Rate

If the country has previously planted the commodity in question, then country-level FBS compilers are recommended to just calculate the seeding rate using data from previous years. This can be done by rearranging equation (3-11) to instead solve for the seeding rate.

$$Seeding\ rate\ \left(\frac{MT}{HA}\right) = \frac{Seed\ use\ (MT)_t}{Sown\ area\ (HA)_{t+1}} \quad (3\text{-}12)$$

This equation is then utilized on previous time periods for which seed use in one year and sown area in the following year have been reported.

If seed use is being estimated for the first time or if FBS compilers wish to ensure that utilized seed rates are current (in other words, that they take into account any changes in technology or shifts in production area that could affect the overall seeding rate), compilers should consult agricultural experts who will most certainly be able to provide an estimate of an average seeding rate (keeping in mind that this average will need to reflect any differences in seeding rates by production system).[65] These experts could be extension agents, research scientists at public institutions, or even persons within seed companies, provided that most utilized seed is purchased every year and does not come from household reserves. Seeding rate estimates from these sources at the country level are likely to be closer to reality than estimates produced by any general global model.

[65] In cases where seeding rates vary greatly by production system, the average seeding rate should be calculated as a weighted average of seeding rates in individual production systems. For example, seeding rates for direct-seeded paddy rice are higher than seeding rates for transplanted rice and system of rice intensification (SRI) techniques. As such, the "average" national seeding rate in these circumstances should be calculated by weighting the average seeding rate of each different technique by its share of planted area.

As a last resort, country-level FBS compilers can consider using seed rates from products in the same commodity group, or even use seed rates for the same product from other similar (typically neighboring) countries.

Step 2: Area Imputation

The statistical programs of many developing countries collect data only on sown area and not harvested area. If an estimate for sown area in the following year is available, then FBS compilers should skip to Step 3, as only sown area and seeding rate are needed to derive an estimate of seed use.

If no estimate for sown area in the following year is available, then sown area must be imputed. This can be done through one of three approaches, depending upon the data available to the country-level compiler: the first approach is preferred but requires other input data, and the second and third approaches are proposed as alternatives.

Approach 1: The Ratio Approach

For countries where historical data is available on both sown and harvested area, then the average ratio of sown area to harvested area over the historical series, $\overline{\text{RatioSH}}$, can be used to impute a quantity estimate for sown area in the following year—provided that an estimate of the area harvested in the following year is available.[66] To derive $\overline{\text{RatioSH}}$, country-level FBS compilers simply need to calculate $RatioSH_t$, the ratio of $\frac{\text{Sown area}}{\text{Harvested area}}$, in each year for which there is a value for both variables, and then average those annual ratios. Once $\overline{\text{RatioSH}}$ has been calculated, then that value can be multiplied by harvested area in the following period, t+1, in order to arrive at an estimate for sown area in that same year, as below:

$$Sown\ area_{t+1} = (\overline{RatioSH}) * Harvested\ area_{t+1} \quad (3\text{-}13)$$

The following scenario will help to illuminate this calculation. Imagine that Country A's FBS compilers have an estimate of harvested area of sunflowers for 2014 of 385 hectares, but no value for sown area for that year. They do, however, have historic data on sown area and harvested area for sunflowers for 2010-2013. To impute sown area then for 2014, the first step needed is to calculate $RatioSH_t$ for each year (step one in Table 3-4). Then each of these annual $RatioSH_t$ values are averaged over the series to derive $\overline{\text{RatioSH}}$ (step 2).

Table 3-4: Hypothetical sown area, harvested area, and RatioSH for sunflowers in Country A

Year	***Sown area (HA) (A)***	***Harvested area (HA) (B)***	$\boldsymbol{RatioSH_t}$ ***(C=A/B)***
2010	400	388	400/388 = 1.03
2011	425	405	425/405 = 1.05
2012	420	395	420/395 = 1.06
2013	390	370	390/370 = 1.05

[66] In instances where sown/harvested areas can vary widely from year to year, compilers may instead wish to calculate $\overline{\text{RatioSH}}$ as a geometric mean, since the geometric mean is less susceptible to extreme values than the arithmetic mean suggested above.

2014	***?***	***385***	$\overline{\boldsymbol{RatıoSH}} = \frac{\mathbf{1.03+1.05+1.06+1.05}}{\mathbf{4}}$ = ***1.05***

Now that Country A FBS compilers have both $\overline{\text{RatıoSH}}$ and harvested area in 2014, they can calculate sown area in 2014 using equation (3-13).

	$\text{Sown area}_{t+1} = (\overline{\text{RatıoSH}}) * \text{Harvested area}_{t+1}$	(3-13)
	$\text{Sown area}_{2014} = (\overline{\text{RatıoSH}}) * \text{Harvested area}_{2014}$ $\text{Sown area}_{2014} = 1.05 * 385$ $\text{Sown area}_{2014} = 404$	

If no estimate of harvested area in the following year is available, then country compilers can substitute the current year's harvested area as a stand-in until data on harvested area in the following year is available.

Approach 2: Abandonment Adjustment

If there is no historical data from which $\overline{\text{RatıoSH}}$ can be calculated but data on harvested area is available, sown area can instead be estimated using the harvested area data and an approximation of the amount of area that is sown but not harvested, which is referred to as the abandonment rate. First, we can begin by using the identity that harvested area is equal to the sown area multiplied by 1 minus whatever percentage of land is abandoned, *abd*.

	$Harvested\ area_{t+1} = (1 - abd)Sown\ area_{t+1}$	(3-14)

Rearranged to solve for sown area, the formula becomes:

	$Sown\ area_{t+1} = \frac{Harvested\ area_{t+1}}{(1 - abd)}$	(3-15)

For example, if Country A harvested 95 hectares of wheat in 2015, and 5 percent of sown area is commonly abandoned before harvest in an average year, equation (3-15) can be utilized to calculate an estimated sown area, which in this case calculates to 100 hectares.

	$Sown\ area_{t+1} = \frac{Harvested\ area_{t+1}}{(1 - abd)}$	(3-15)
	$Sown\ area_{2015} = \frac{95}{(1-0.05)}$ $Sown\ area_{2015} = 100$	

Approach 3: Using harvested area as an approximation for sown area

If it is not possible to calculate a historical ratio of sown to harvested area and an estimate of land abandonment is not possible, but data on harvested area is available, then as a final option, country-level FBS compilers can use harvested area in the following year to approximate sown area in the following year. This approach is equivalent to calculating sown area using either a $\overline{RatioSH}$ of 1 in Approach 1, or an abd rate of 0 in Approach 2. It should be emphasized that this approach should only be used when either of the two options above are not possible, as no accounting for land abandonment will lead to chronic underestimating of seed use in the previous year.

Step 3: Multiply the two values

Once a seeding rate and sown area in *t+1* have been estimated for the product in question, the two values are multiplied to arrive at the quantity of seed needed in year *t*.

3.5.8 Tourist Food

Historically, food available for consumption by tourists and other visitors was not included as a separate category in most food balance sheet exercises. Instead, these quantities were assumed to be covered by the catchall category, "other utilizations." But estimating food available for consumption by visitors independently is encouraged for two reasons. First, data on visitor arrivals is widely accessible, such that it is possible for all countries to more specifically account for tourist food in their food balance sheets. Second, for some countries—particularly Small Island States—large quantities of visitors relative to the resident population have the potential to substantially alter the balance sheet landscape. For example, the UN Population Division reports that in 2013, the population of the Caribbean nation of St. Lucia was 182,000 people. In that same year, the UN World Tourism Organization (UNWTO) reported that the country had 921,000 visitors, including 602,000 same-day visitors and 319,000 overnights visitors, who stayed an average of 8.9 days (UNWTO, 2016). This concept of large visiting populations is also applicable to countries with large migratory labor forces. That is, if the country compiling the FBS has a large seasonal immigrant workforce who are not counted in population estimates as residents, then the food available to those migrant labor forces needs to be somehow accounted for. In cases such as these, it is evident that not specifically accounting for food available for consumption by non-resident visitors (regardless of the duration of their stay) would lead to overestimation of food available for consumption by local populations.

Likewise, days that a country's residents spend abroad should not be counted in domestic food availability, given that those persons are not at home to consume food, and food consumed abroad will be counted in tourist food figures of other countries. For this reason, estimating tourist food should be done in *net* terms. That is, net tourist food should be calculated by subtracting the food that would otherwise be available to a country's outbound travelers from the amount of food available to inbound visitors. As a consequence, it is likely that this information in the balance sheet will need to be populated through imputation, derived using numbers of visitors, visit lengths, and the amount of calories historically available in the home and destination countries. This input data for the imputation can be drawn from a mixture of both official and semi-official sources, as detailed below.

It should be emphasized here that country-level compilers should ensure that all persons consuming food within a given country are accounted for either as resident population (accounted for in food availability) or as visitors (accounted for in tourism food). This concept is straightforward when it comes to tourists, but may not be so evident when it comes to temporary migrants, who may spend months away from home. How these populations are classified may depend upon the country, but the following should always apply: if an FBS compiling country's outgoing migrants are counted as part of the resident population in their country of origin, then the number of visitor-days spent outside the country should be subtracted from tourist food, but if outgoing migrants are counted as non-residents in their country of origin, then any days they spend back in their country of origin should be added to tourist food.

Of course, cases such as the Small Island State example described above affect only a small subset of countries, and migrant worker populations may be minor as well, such that many country-level FBS compilers may not find it worthwhile to estimate tourist food separately. Nevertheless, the general approach is outlined here, and full details on the necessary calculations are available in Appendix 1.

3.5.8.1 Official data sources

While data on arrivals and departures may be collected by immigration authorities, it is likely that national tourism offices in each country will be the entity that publishes the most detailed information available on visitor arrivals and departures. This data should be differentiated by country of origin, and include numbers of both day visitors and overnight visitors, as well as the average length of stay for overnight visitors.

Through surveys, tourism boards may also publish figures on tourist food consumption patterns, which would certainly aid FBS compilers in estimating tourist food within the balance sheets.

3.5.8.2 Alternative data sources

If FBS compilers do not have ready access to their country's data on visitor arrivals, they may instead consult reports from the UN World Tourism Organization (UNWTO).[67] This organization compiles and publishes member country-provided data on the number of visitors[68], average length of stay, and country of origin, as well as estimates on outbound tourism. Although no data on tourist food consumption is included, as above, the number of arrivals is a useful starting point for estimating tourist food.

It is possible that industry groups may have more detailed data about actual visitor food consumption—possibly including how tourist consumption patterns differ from the local population, or even the quantities of certain foods consumed by tourists. If such information is not available from industry groups, it is possible that for countries where tourism is clustered mostly into resort areas, sales or tax records from those establishments could be used as a first-level approximation of tourist food and then extrapolated to the entire tourist population using the appropriate weights.

[67] Although access to all data and reports requires a subscription, basic data on number of arrivals and country of origin for overnight visitors is available free of charge. See http://www.e-unwto.org/toc/unwtotfb/current.
[68] Although the data is produced by the World Tourism Organization, it includes data on both personal and business travelers. For that reason, it is more accurate to refer to arrivals as "visitors" rather than just "tourists."

3.5.8.3 Imputation and estimation

The approach to imputing tourist food is merely a calculation and not an econometric model. However, given the number of steps involved in the calculation and the reality that many countries may decide not to estimate tourist food separately, for brevity's sake, only the basic approach is outlined here in the text. Instead, a step-by-step guide on how to calculate net tourist food is included in Appendix 1.

Net tourist food is simply the amount of food available to incoming visitors minus the amount of food that would have been available to residents had they been present in the country. For each commodity, this amount can be calculated by first multiplying the number of incoming visitor days by the average daily food availability of that commodity, and then subtracting from this value the product of the number of outgoing traveler days and the average daily food availability for that commodity (3-16).

$$NetTF = [\#Incoming\ visitor\ days * Daily\ food\ availability\ for\ visitors] - [\#Outgoing\ traveler\ days * Daily\ food\ availability\ for\ residents] \quad (3\text{-}16)$$

In calculating the daily food available for consumption by tourists, the imputation process also assumes that incoming visitors follow the consumption pattern of the local population (that is, they experience the same dietary food availability shares of given products as in the countries they are visiting), but they continue to expect the same overall amount of calorie availability as in their home country. This is done simply by scaling quantities of an individual commodity by the ratio of overall food availability in the two countries. For example, if food availability in Country A is 30 percent greater than in Country B, all quantities of food available for consumption for visitors from Country A to Country B would be scaled up by 30 percent when compared to food available for the local population. The specific of this approach are outlined in Appendix 1.

If country-level compilers cannot access data on visitor country-of-origin, but still wish to account for "Tourist Food" in their balance sheet, a simplified calculation is suggested—compilers can also just assume that visitors experience the same food availability for each commodity as does a resident. This approach may underestimate total "Tourist Food", but it is a preferable approach to relegating food available for visitors to a residual component.

Again, more guidance on the recommended calculation is provided in Appendix 1, but this brief overview should be sufficient to inform country-level compilers of the basic idea, should they consider it relevant to their case to introduce net tourist food as a separate variable in their balance sheets.

3.5.9 Industrial Use

As defined in section 2.2.1, "industrial use" refers to utilization of any food items in any non-food industry. Industrial uses of agricultural products have been growing over the past few decades, to a large extent driven by the expansion of the biofuels market. For example, corn, rapeseed, soy, and sugarcane may all be used for this application in certain countries. But industrial applications are also growing for other commodities, such as palm oil and coconut oil, which are used in many cosmetics. In addition, many crop byproducts may have industrial applications. As two examples, wheat starch is commonly used in the paper industry, and limonene—produced from orange peels as a byproduct of the juicing process—is a common ingredient in many cleaning products.

Because industrial uses of agricultural products are very context-specific, it is not possible to provide universally-applicable advice on data sources or imputation methodologies for this balance sheet variable. Instead, compilers are encouraged to first seek out industry and commodity experts (both in the public and private sector) to investigate which products are utilized for industrial purposes in their respective countries, and how their use can be modeled in cases of missing data. Nevertheless, some guidance on potential data sources is provided.

3.5.9.1 Official data sources

Country FBS compilers are first encouraged to consult any official data sources about the possibility of industrial uses of any commodities. Countries with large industrial utilizations of certain products may collect data on the quantity or share of production that is destined for such uses in either an annual statistical yearbook or industry-specific input-output tables. If during the process of the data assessment, it is discovered that there is a large amount of industrial use of a certain product that is not captured in current official surveys or input-output data, countries are encouraged to consider collecting official data on those uses, which will better inform markets and facilitate FBS compilation.

3.5.9.2 Alternative data sources

For countries where no official data collection on industrial uses is currently taking place, compilers have some alternatives. In some countries, it may be possible to obtain estimates of industrial uses by accessing purchase or sales records from private agro-industrial companies. Particularly in countries where processing of a given commodity for industrial uses is concentrated in the hands of a few processors, consulting those companies could provide valuable information for populating the FBS. Some estimates on industrial uses may also be obtained directly from commodity associations, who likely already consult with or get information directly from agroprocessors.

In cases where industrial uses are almost entirely biofuel-related, countries may be able to use the current policy framework to assist in estimating industrial use data. For example, if a country has implemented a biofuels mandate, then those thresholds may be useful in inferring industrial utilizations.

In cases where none of these strategies seem feasible, countries can also consult two additional data sources, which largely cover biofuel uses. The first of these is the OECD/FAO medium-term outlook, which provides estimates of ethanol production, biodiesel production, and biofuel use for a selection of the world's countries.[69] Compilers may also wish to consult the USDA's Production, Supply and Distribution (PS&D) database estimates for "Industrial Domestic

[69] This database can be accessed at: http://www.agri-outlook.org/database/.

Consumption” of oil crops. These estimates are typically derived from reports of U.S. agricultural attaches, and may provide a useful starting point for FBS compilation.[70]

3.5.9.3 Imputation and estimation

At present, there is no suggested imputation methodology for industrial uses—partly because industrial uses tend to be strongly related to the contexts of specific commodities and countries. In order to ensure that industrial uses are properly accounted for in the balance sheet framework, compilers are encouraged to focus their efforts on consulting with commodity experts, and advocating for official data collection if industrial uses are found to be large.

3.5.10 Loss

Recall that for the purposes of the food balance sheet, “loss” most closely aligns with “post-harvest/post-slaughter loss”, representing quantities of food that leave the production/supply chain at any stage from post-harvest up to the retail level (the level of the supply chain at which “food availability” is defined). The accurate measurement or imputation of loss is important for both its effect on the balance overall balance (not estimating loss could result in dramatically higher estimates of food availability, or of any of the other utilizations, for that matter) and as a means to help countries identify problems in production/particular supply chains to underpin policy efforts seeking to maximize resource efficiency. Food loss is problematic because it is both a squandering of resources (for example, the land used to produce food that no one eats could instead have been dedicated to carbon sequestration) and an environmental problem in its own right (because rotting food emits methane gas), not to mention the untapped potential of that lost food to feed the world’s nearly 800 million hungry people. However, in order to most effectively target food loss interventions, loss must first be measured.

3.5.10.1 Official data sources

For the reasons elaborated above, countries are increasingly attempting to measure or estimate loss as part of their overall agricultural statistical programs. It is recommended that countries use targeted surveys to measure loss. This may include surveying loss in on-farm operations and storage, loss in warehouses or collection points, loss in transportation, and loss in public storage. While surveying for information on loss can be expensive, there are recommendations that countries can follow to reduce these costs, such as including a module on loss in annual production surveys at the farm level. The Global Strategy has already produced a Methodological Report on the measurement of post-harvest loss of grains and is planning to publish Guidelines on this topic in 2017.

For countries holding large public food stocks—particularly of cereals—access to data on the loss both in public storage facilities and loss occurring during the transportation of these publicly-held stocks is essential to accurate estimation of overall loss. Without such data, loss is likely to be severely underestimated.

3.5.10.2 Alternative data sources

[70] The PSD database is available at: https://apps.fas.usda.gov/psdonline/app/index.html#/app/home.

For most countries, at least some data on loss in specific segments of the supply chain will likely be available outside of official sources, as loss incur real-world economic costs on supply chain actors. At a minimum, country-level FBS compilers are encouraged to consult warehouse managers and transportation firms or associations for a basic understanding of the scale of loss for the most important commodities.

In addition, country-level FBS compilers are advised to seek out case study investigations of that may contain loss estimates for particular sectors. Compilers are, however, encouraged to consider the statistical validity of the data, particularly its representativeness of the target population, before adopting an estimate published in a sector case study.

3.5.10.3 Imputation and estimation

In the absence of data from official sources or information from alternative data sources at the country level, loss should be imputed for each primary commodity. The approach that countries follow will be highly dependent upon the historic availability of data on post-harvest/post-slaughter loss for that country.

Suggested Approach

In cases where some historic data is available, it may be optimal to estimate loss through a regression approach, such that loss is modeled as a function of certain other variables (potentially including covariates like maximum temperature in the harvest areas, average moisture level of grain, miles of paved roads per square kilometer, refrigerated storage capacity, or distance of main producing areas from the main terminal markets). Countries are encouraged to assess their particular situation on loss, including identifying critical loss segments in each supply chain, in order to determine whether or not their imputation would improve through the usage of such an approach.

In instances where no historical data on loss exists, country-level FBS compilers are advised to scour any relevant available information that might inform an estimate of loss. This may include scaling up estimates from case studies, convening focus groups of supply chain experts, consulting industry organizations, or conducting controlled experiments or pilot studies to form some idea of the share of production (or share of supply) that ends up as loss. Then this percentage can be applied to production (or supply) in subsequent years to impute a value for loss, as in equation (3-17).

$$Quantity\ of\ Loss = Quantity\ of\ Production * Estimated\ \%\ Loss \tag{3-17}$$

Alternative Approach

If no local information is available, then country-level FBS compilers may instead consider imputing loss by relying on the available pool of global loss information. In essence, country-level compilers can estimate their loss using official data from countries that *do* report loss. This is done by estimating the relationship between officially-reported production levels (or officially-reported supply levels, but as official data on stock levels is relatively rare, it is recommended that countries use only production data in their estimations) and officially-reported loss (for either the product in question or for similar goods) using what is called a hierarchical linear model.[71] This type of model uses nested data, where groups of units are clustered together in an organized fashion, such as "commodities" within "geographic areas" within "overarching commodity groups." This data is then organized into levels, where the first level is most specific and the highest level is broader. Conceptually, the approach is as follows:

1) If data on loss for a particular commodity in a particular country is reported, then no imputation is necessary, if not:
2) Loss of that commodity in that country is imputed by estimating the relationship between production and all other independent variables and loss of that commodity in all other countries of the world that reported official data on loss, and then using that relationship to calculate likely loss in the country in question. If no official data are reported for that commodity for any country in the world, then:
3) Loss of that commodity in that country are imputed by estimating the relationship between production and all other independent variables and loss of all commodities from the same commodity group as the commodity in question for all other countries of the world that reported official data on loss, and then using that relationship to calculate likely loss in the country in question.

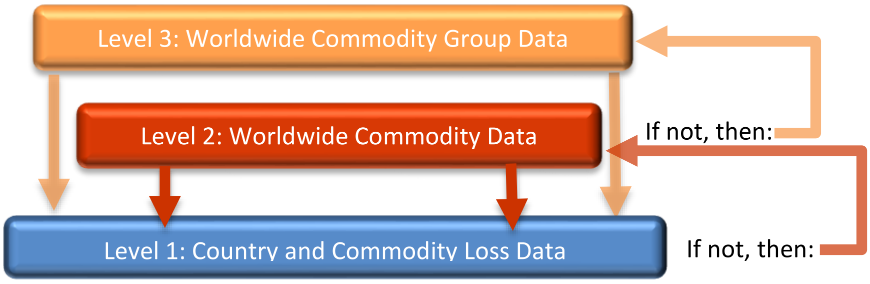
Estimating loss in this manner then requires that countries consult a data resource where other countries have reported official estimates for both loss and production. This data can be accessed in the FAO-compiled food balance sheets.

[71] For more information on this approach, see Gelman & Hill (2007).

Box 3-1: Example of imputation of loss using a hierarchical approach

A practical example and graphical representation of the application of the hierarchical linear model for the imputation of loss should facilitate understanding of this structure. Say that an FBS compiler from Country A is attempting to impute loss for wheat. Country A does not collect data on wheat loss (level 1), so an imputation is necessary. Thankfully, many other countries *do* measure loss of wheat. So Country A can use estimate the average relationship between loss of wheat and production on a global level (level 2), and then use that relationship to calculate an imputed value for their loss of wheat. In this case, the only information used from the hierarchy would be level 2—there is no data for level 1 and because data on level 2 was available, the compiler did not need to proceed up the hierarchy (Box Figure 1).

BOX FIGURE 1



Let's say that in addition to wheat, Country A needs to impute loss of oats. Because Country A does not collect data on oats, they automatically proceed to level 2…the relationship between production and loss of oats at the global level. However (at least for the purposes of this hypothetical illustration), they discover that no other countries are reporting official data on loss of oats either. In this case, the compilers would proceed to level 3. Because oats are a cereal grain, the compilers would first estimate the relationship between loss and production for all countries for all cereal grains, and then use that relationship to calculate an imputed value Country A's loss of oats.

3.5.11 Residual and other uses

Residual and other uses is a unique balance sheet element, in that its purpose and calculation will vary depending upon the needs of the country in question (indeed, the individual country may not wish to utilize this category at all, entirely dropping it from the balance sheet).

First of all, this category can be calculated ex-post as a balancing item at the SUA level. As such, it would be estimated in a manner similar to that of the "imbalance" in the supply = utilization identity, after quantities have been estimated for each of the other variables. However, as elaborated in earlier sections, this strategy should only be utilized when the imbalances in the equation are small.

There may also be cases where "residual and other uses" is utilized to capture some category that the country itself deems important to include in the FBS. While these Guidelines have strived to cover all possible commodity utilizations with the previously identified categories, it is possible that there are additional uses for certain commodities in certain countries that country-level FBS compilers will want to account for separately (food available for consumption by refugees is one possibility). In this case, no specific data sources or imputation methods can be recommended, but users are encouraged to consult experts on the commodity supply chain in question in order to determine if said variable is being or can be measured, and if not, how it can be reliably estimated.

3.5.12 Additional parameters

Population

In the calculation of country-level FBS, compilers have the option of using either domestically-produced or internationally-standardized population estimates from UNPD. Domestically-produced estimates and the UNPD estimates may diverge if certain groups are counted in domestically-produced figures, but are excluded from UNPD figures (or vice versa). As such, it is up to the compiling country to come to a decision on which population estimate they should use for the purposes of FBS compilation. It is important to recognize that the choice of population data will directly impact the final DES figures, so the rationale for choosing one figure over the other should be discussed and documented by an FBS technical working group. This decision should be based upon which figure better captures the full picture of a country's resident population (counting undocumented workers, refugees, etc.). In many instances, national population data may better account for these resident groups.

Countries may find that using UNPD population data instead has its own advantages. UNPD data are produced according to a standardized, internationally-recognized methodology, which facilitates comparison between countries. Furthermore, the estimates from UNPD are used as a common denominator for deriving per capita estimates under global development initiatives, including the recently-concluded Millennium Development Goals and the now-underway Sustainable Development Goals. If compilers choose to use this data, it is publicly-available and can be easily accessed from the following site: https://esa.un.org/unpd/wpp/.

If there are large differences between nationally-produced population estimates and UNPD figures, countries are encouraged to clarify the underlying explanation behind the discrepancies with UNPD to hopefully better reconcile the two estimates.

Nutrient estimates

As described in section 2.2.2, the relevant nutrient estimates that are at present commonly covered in FBS composition are energy (expressed in kcal), protein (expressed in g), and fat (also expressed in g). Data on nutrient content are available from various sources, but two international sources should be noted for their relevance to the process of FBS compilation:

- FAO and the International Network of Food Data Systems (INFOODS) publishes an international food composition table and database directory, here: http://www.fao.org/infoods/infoods/tables-and-databases/en/. Included on this site are links to various regional and country-specific food composition tables. In addition, the FAO/INFOODS Analytical Food Composition Database (AnFooD1.1) contains analytical food composition data on specific foods from all over the world.

- FAO publishes the conversion table that its Statistics Division uses in the composition of FBS here: http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Food_security/Excel_sheets/Nutritive_Factors.xls).

Despite the existence of these internationally-compiled resources, it is recommended that country-level FBS compilers first check to see whether or not such a nationally-produced conversion table exists before using another source table. This is because the nutrient content of products may vary slightly depending upon the characteristics of the variety of the product that is consumed. As such, if no national estimates are available, it is recommended that countries first consult tables from their own region or neighboring countries before using an international reference table.

It should also be emphasized here that countries should note whether their reference nutrient tables are done on the basis of gross or net product weight. That is, do the per ton nutrient conversions take into account inedible parts, or should inedible parts first be subtracted from food quantities through the appropriate application of some refuse factor.

Extraction rates

Extraction rates for processed products vary by country according to the technologies utilized, and in some cases may vary based on the specific properties of the input products used in that country. These rates may increase over time as improved technologies are adopted, but rates tend to change little from year-to-year. Keeping this in mind, compilers are encouraged to hold extraction rates fixed in their FBS calculations. This simplification is recommended because only in a few rare instances in developed countries are both the inputted quantity of raw material and the outputted quantity of processed product actually measured, which would be the necessary condition for the endogenous calculation of an extraction rate. Additionally, very few countries separately publish/update their average extraction rates annually. In contrast, the more common circumstance is one where the output of a processed product is known, but the input is not. For example, countries may publish an estimate of their production of apple juice, but not the quantity of apples used as input in that transformation process.

The second reason that fixed extraction rates are recommended is the observed tendency to overestimate quantities assigned to food processing while simultaneously underestimating (or leaving out altogether) other uses of a product. Carrying on with the above example of apples, this would be equivalent to assuming that all apples not consumed in the fresh market were processed into juice with no accounting for loss on the utilization side of the equation. In this instance, an overestimation of the amount of input due to missed accounting for loss would lead to the deriving of lower-than-expected extraction rate. The last reason that the usage of fixed extraction rates is recommended is to aid the standardization process, such that the parameter used to convert derived products back to primary equivalents remains unchanged from year to year. Even so, countries are encouraged to periodically review their extraction rates to ensure their accuracy.

In sourcing extraction rates, countries are encouraged to speak directly to domestic processors to either collect data on or more accurately estimate national extraction rates. More structured supply chain studies (potentially including research student theses or dissertations) may also be a useful source of information, provided that they are sufficiently representative. Focus group discussions including industry experts and researchers could also be a useful source of extraction rate data.

As a last resort, FBS compilers can consult the handbook on average technical conversion factors that is publicly available on FAO's website, here: http://www.fao.org/fileadmin/templates/ess/documents/methodology/tcf.pdf. However, FBS compilers should note that this document was produced in 1999, in some cases based on data that may already have been more than a decade old, and thus this document does not capture any recent innovations in food processing technologies.

Processing shares

Processing shares are extremely dependent upon the structure of each country's particular product supply chains (as laid out in country-specific commodity trees). As such, there are no international sources that can be consulted in the search for processing shares data. Instead, it is recommended that country-level FBS compilers consult any available supply chain analysis investigations as possible data sources. Industry experts may be also be consulted, as they may be able to provide certain insights into the supply chain that would assist FBS compilers in estimating likely processing shares.

3.6 Summary

This chapter has focused intensively on the data necessary to compile FBS. The process of compiling data should begin with the establishment of a TWG that defines the scope of the work and assigns data responsibilities among the different TWG participants. Then the data search process can begin, keeping in mind that data should be comparable by product, unit, and reference period. The topic of data quality considerations, including the application of flags and assigning of *a priori* tolerance intervals was then discussed, and advice on performing the data search and assessment was then provided. The chapter then offered suggested data sources and imputation approaches for all variables in the FBS. Once all of the data is in hand, FBS compilers can move on to fitting the data together in the FBS framework, which will be covered in detail in Chapter 4.

4

Step-by-step guide to FBS construction

4.1 Introduction

As emphasized in previous chapters, the bulk of the work in compiling country-level FBS actually takes place in the preparatory stages—identifying data sources and making adjustments to ensure that data are comparable (including the filling of a data assessment grid), followed by the imputation of values for any missing data in the balance sheet. Once this has been done, the task of compiling the actual supply utilization accounts for commodities should proceed more quickly. This requires first filling in the empty SUA tables, balancing SUA level commodities, standardizing and aggregating products in the SUA to primary commodity equivalent level, balancing the identity at the primary commodity level, converting food values from volumes to dietary equivalents, and finally deriving per capita dietary estimates. This chapter will outline this process by tracing the development of an FBS account for one commodity tree—oats.

4.2 Filling SUA table

Once the first two steps in the FBS compilation process have been completed (data assessment and imputation of any missing data, covered in the previous chapter), FBS compilers can proceed with filling the blank SUA table for each commodity in question. This process begins with the consulting of the relevant commodity tree to ensure that the primary commodity and all derived products are accounted for. For oats, the commodity tree includes the primary product, plus two derived co-products that result from the milling process: rolled oats and bran of oats.[72] Once this information has been verified, the blank SUA table can be set up, such that the columns account for all utilizations, each product in the commodity tree has its own row, and the first row is reserved for the primary commodity (Table 4-1). Note that in this example, the compilers chose not to include a "Residual and other uses" variable in their calculations. As such, it is excluded from the tables.

Table 4-1: Blank oats SUA table

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	-	-	-	-	-	-	-	-	-	-	-
Rolled oats	-	-	-	-	-	-	-	-	-	-	-
Bran of oats	-	-	-	-	-	-	-	-	-	-	-

[72] It should be noted here that other products can be derived from oats (including breakfast cereals, cereal preparations, and distilled alcoholic beverages), but in this particular example, oats are only processed into the above goods.

From this blank table, FBS compilers should start filling in the different supply and utilization variables, beginning from the left-hand side with production. At this stage, compilers should keep in mind that for some derived products, production will be filled only after quantities have been estimated for amounts sent to processing.

In our sample case, the filling of the SUA table begins with official figures for production for both oats and rolled oats (one coming from an agricultural survey, and one from an industrial output survey) (Table 4-2). Because we know from the commodity tree that bran of oats and rolled oats are co-products, we know that there must be production of oat bran also. However, there is no official figure for oat bran production, so it is not included at this time. Instead, as alluded to above, a figure for oat bran production will be derived after a number for food processing has been entered.

Table 4-2: Oats SUA table with official production data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	-	-	-	-	-	-	-	-	-	-
Rolled oats	54,789	-	-	-	-	-	-	-	-	-	-
Bran of oats	-	-	-	-	-	-	-	-	-	-	-

Next, official trade data is added (Table 4-3). Analysts should note at this step that there is no harmonized HS6 category for either rolled oats or bran of oats. Instead, countries may either have a more detailed breakout at the 8- or 10-digit level for these products, or else trade data for these two products would be included under some other HS6 basket category (likely covering bran or worked grains for other cereals not elsewhere defined in the HS classification). In this second case, country-level analysts would need to estimate what proportion of the relevant 6-digit basket category these products represent, and then estimate or impute some value for trade. In this example, however, the hypothetical country in question has a more detailed trade breakout at the HS 8-digit level, such that trade data for rolled oats and bran of oats are collected under specific individual 8-digit codes that can be added directly to the table.

Table 4-3: Oats SUA table with official trade data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	-	-	-	-	-	-	-	-
Rolled oats	54,789	14,074	2,130	-	-	-	-	-	-	-	-
Bran of oats	-	688	1,436	-	-	-	-	-	-	-	-

Once trade has been added to the table, stocks changes can be accounted for (Table 4-4). Because oats are a grain, they can be stored from one year to the next. However, very few countries collect comprehensive data on total stock levels (which include public stocks, private commercial stocks, farm-level stocks, and, in some cases, consumer-held stocks) through surveys.[73] Instead, stock changes must be imputed, or stock levels must be estimated. In line with this situation, the country in our example does not collect data on stock levels, so a value of stock change is imputed using a model (refer to section 3.5.3.3 for an example).

Stocks are not kept (or accounted for) for many derived commodities. This is usually the case for derived grain products like flour and bran, as the shelf-life of flour can be considered to be only a few months, while whole, unprocessed cereal grains can be stored for more than one year. By contrast, stock-keeping is common for some derived commodities (such as cheese, juice, or olive oil). FBS compilers should be aware of the form in which commodities are typically stored in order to ensure that they are correctly imputing stock levels. In the case of oats, however, stocks are kept in the raw, unprocessed form. Reflecting that fact, zeros have been added to Table 4-4 in the "stock changes" column for both rolled oats and bran of oats.

Table 4-4: Oats SUA table with imputed stock change data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	-	-	-	-	-	-	-
Rolled oats	54,789	14,074	2,130	0	-	-	-	-	-	-	-
Bran of oats	-	688	1,436	0	-	-	-	-	-	-	-

Next, the variables of food and food processing should be addressed. As with most cereal grains, oats are not typically eaten in their primary form, so there will be no "food" estimate for the primary good. Instead, the primary product (in this case, oats) is processed into a derived commodity (rolled oats in this example), which are *then* consumed as food—thus, in lieu of accounting for food at the primary level, there should be some accounting for "food processing" of oats here. Analysts should note that the "food" value for the primary equivalent will come later once the "food" value for rolled oats is aggregated up to the primary equivalent level. The value for "food processing" will be dropped in the same step.

In order to account for food processing, production of all derived goods should be converted back to their primary equivalent (if data on their production is available). In this example, since rolled oats and bran of oats are co-products, all that is needed is a conversion back of the production of rolled oats into amount of oats sent to food processing through an application of the extraction rate using equation (2-8). In this case, the extraction rate for rolled oats from unprocessed oats is 0.65. As such, the calculation proceeds as follows:

$$Quantity\ of\ input = \frac{Quantity\ of\ output}{Extraction\ rate} \quad (2\text{-}8)$$

$$Quantity\ of\ input = \frac{54{,}789\ \text{MT rolled oats}}{\frac{0.65\ \text{MT rolled oats}}{1\ \text{MT oats}}}$$

$$Quantity\ of\ input = 84{,}291\ \text{MT oats}$$

[73] See AMIS (2015) for more information on the status of global measurement of agricultural stocks.

Once this value of processed oats has been calculated, it can be added to the SUA table (Table 4-5). Since rolled oats and bran of oats are not further processed, we can also add zeros to the table under "food processing" for those products.

Table 4-5: Oats SUA table with calculated food processing data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	-	84,291	-	-	-	-	-
Rolled oats	54,789	14,074	2,130	0	-	0	-	-	-	-	-
Bran of oats	-	688	1,436	0	-	0	-	-	-	-	-

It is important to note here that this particular example—where there is official production data for a derived product—may not be characteristic of most developing country supply chains. As such, it would not be possible to calculate "food processing" by working backward from the production of the derived products. Instead, a value for food processing would need to be imputed, and then that value would need to be directed toward particular transformation processes using processing shares, with the end goal of calculating production of the derived commodities (see Box 2-1). Keep in mind that the calculated production of the derived commodities would be subject to the constraint that production of all derived goods is sufficient to cover net trade. That is, if production of a derived commodity calculated from an imputed "food processing" value is not sufficient to cover net trade, then the "food processing" value will need to be raised to a level that would cover production net of trade.

Because we now have a value for amount of oats sent to processing, we can apply that extraction rate and calculate a number for production of bran of oats. To do so, we consult equation (2-7), as follows:

$$Quantity\ of\ output = Quantity\ of\ input * Extraction\ rate \quad (2\text{-}7)$$

$$Quantity\ of\ output = 84{,}291 \text{ MT oats} * \frac{0.20 \text{ MT bran of oats}}{1 \text{ MT oats}}$$

$$Quantity\ of\ output = 16{,}858 \text{ MT bran of oats}$$

This value is then added to the table (Table 4-6).

Table 4-6: Oats SUA table with calculated bran of oats production data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	-	84,291	-	-	-	-	-
Rolled oats	54,789	14,074	2,130	0	-	0	-	-	-	-	-
Bran of oats	16,858	688	1,436	0	-	0	-	-	-	-	-

As described above, the only product in the oats tree in this example that is consumed by humans is rolled oats. As such, a value for rolled oats used as food must be filled in this step. For the sake of this illustration, we assume that there is no official data on food availability of oats, so the value must be imputed. There are a couple of options as to how this can be accomplished. First of all, food could simply be treated as the balancer in the equation after all other uses have been accounted for. If this approach is adopted, then the value for food should be left unfilled until the other utilizations have been accounted for, given that this is a derived good produced solely for human consumption. If this approach is chosen, a value will need to be imputed for net tourist food before food could be used to balance the SUA level account for rolled oats. The second option is to independently impute a value for food utilization using a model that is based on historic food availability data, but which takes into account population and income growth. For the sake of this illustration, let's assume that the value is imputed. The results of this imputation are then added to the table (Table 4-7). We can also add a 0 for both regular oats and bran of oats used for food, since neither product is utilized in that way.

Table 4-7: Oats SUA table with imputed food data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	-	-	-	-	-
Rolled oats	54,789	14,074	2,130	0	66,700	0	-	-	-	-	-
Bran of oats	16,858	688	1,436	0	0	0	-	-	-	-	-

Feed is the next component in the balance sheet. In this example case, two of the products in the tree are used for feed, so these will both need to be filled, but the strategy for doing so will differ somewhat for each product. First of all, let's assume that the sample country surveys both farmers and animal feeding operations in order to publish official data on feed use of oats. This number can be added directly to the table on the line for the primary commodity (Table 4-8). With respect to rolled oats, a zero can be added to the table, as this product is not used for feed. Lastly, considering feed use of bran of oats, although we do not have an estimate of this quantity, we do know that the primary utilization of bran of oats is for feed. As such, feed will balance this product's SUA. For this reason, we can leave this cell blank for the time being while estimates for the other utilizations are considered.

Table 4-8: Oats SUA table with official feed data on oats added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	-	-	-	-
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	-	-	-	-
Bran of oats	16,858	688	1,436	0	0	0	-	-	-	-	-

From feed, we move on to seed. In this scenario, the country does not collect data on seed use. However, an average seeding rate and the value of sown area in the subsequent year are both available in this scenario, such that imputing a value for seed use is possible. As seed is only relevant for the primary commodity, the rest of the column can be filled with zeros (Table 4-9).

Table 4-9: Oats SUA table with imputed seed use data added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	-	-	-
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	0	-	-	-
Bran of oats	16,858	688	1,436	0	0	0	-	0	-	-	-

Next, net tourist food is considered for every product that is consumed as food. For countries where net tourist food is likely to be negligible, country-level compilers may wish to either eliminate this variable entirely from their balance sheets, or keep the variable but estimate the value as “0” for the time being as a consideration that this value may be estimated in future. For countries wishing to consider net tourist food, this value can be imputed according to the approach laid out in section 3.5.8.3 and described in detail in Appendix 1, which uses incoming and outgoing tourist flows and historical food availability data to estimate the likely quantity of food available for consumption by incoming tourists, net of food that would have been available for consumption to domestic residents that traveled abroad. This imputed value is then added to the table (Table 4-10). Note that in this case, the positive value on net tourist food indicates that incoming tourists are consuming more rolled oats than are outgoing residents. Again, as with food, since rolled oats are the only product that can be used for food by tourists, zeros are added for the other commodities in the tourist food column.

Table 4-10: Oats SUA table with imputed tourist food added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	0	-	-
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	0	750	-	-
Bran of oats	16,858	688	1,436	0	0	0	-	0	0	-	-

After tourist food, we move on to industrial use. In this example case, FBS compilers in the country know from industry experts that some outgraded oats not used for feed are diverted to industry to be processed into soaps and lotions. This quantity is not known with certainty, and there is no methodology to impute the value, so it is estimated according to the best available information, such using market data from industry organizations. This value is then added to the table, and zeros fill the remaining rows in the column (Table 4-11).

Table 4-11: Oats SUA with estimated industrial use added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	0	2,500	-
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	0	750	0	-
Bran of oats	16,858	688	1,436	0	0	0	-	0	0	0	-

The last variable to be filled is loss. Many countries are not yet collecting data on loss of all products. Partly due to this scarcity of data, for now, countries may choose to either use estimations or country-specific econometric models. Failing these options, loss may be imputed at the primary commodity level according to the approach described in section 3.5.10.3. Once this value has been imputed according to the chosen method, the value is added to the table, and zeros fill the remaining rows (Table 4-12).

Table 4-12: Oats SUA with imputed loss added

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	0	2,500	3,940
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	0	750	0	0
Bran of oats	16,858	688	1,436	0	0	0	-	0	0	0	0

Once loss has been added to the table, all variables have been accounted for in each of the SUA accounts.

4.3 Balancing SUA accounts for derived commodities

Before standardization and aggregation up to the primary commodity level can begin, FBS analysts must first check that derived product accounts are balanced. To do so, a calculation is made at this step to check that the supply = utilization identity holds for the derived commodities (Table 4-13).

Table 4-13: Balance check on SUA accounts for commodities derived from oats

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*	*Imbalance*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	0	2,500	3,940	
Rolled oats	54,789	14,074	2,130	0	66,700	0	0	0	750	0	0	-717
Bran of oats	16,858	688	1,436	0	0	0	-	0	0	0	0	16,110

In this case, balancing the account for bran of oats is straightforward, as we had already noted that feed should be the primary utilization for this product. For this reason, the imbalance in this line is assigned to feed. However, the case for rolled oats is slightly different. Because production, imports, and exports are all official data that should remain unchanged, the only way this account can be balanced is if the imbalance is absorbed by either food or net tourist food, which were both imputed using models.

Since the accounts may be adjusted again after the standardization process, it is recommended that at this stage the imbalance be absorbed by the largest utilization. In this case, food is by far the largest non-official utilization, so the adjustment should be made here. Below in Table 4-14, you see that food use has been reduced, and the equation now balances.

Table 4-14: Balanced SUAs for products derived from oats

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Food processing*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*	*Imbalance*
Oats	131,259	188,219	3,439	12,350	0	84,291	182,950	12,300	0	2,500	3,940	
Rolled oats	54,789	14,074	2,130	0	65,983	0	0	0	750	0	0	0
Bran of oats	16,858	688	1,436	0	0	0	16,110	0	0	0	0	0

From here, the standardization process can begin.

4.4 Standardization and Aggregation

Recall from section 2.3 that in order to arrive at a single FBS account at the FBS level, the SUA accounts must be standardized (that is, converted back to their primary commodity equivalent) before they can be added together. This process of standardization is accomplished by dividing by the extraction rate and then adding all the values together. However, only the values of *certain* variables are added together in the standardization process. In this section, we proceed variable by variable to precisely outline this process.

However, before beginning, it is imperative to note that in order to avoid double-counting, only one commodity from each transformation process is standardized and aggregated. Because the goal of this process is to produce food balance sheets, this means that the product that is standardized will typically be the one that makes the largest contribution to food. That also means that commodities like bran, which is a co-product of the flour milling process whose primary utilization is feed, are not standardized and aggregated in this framework. This point will be re-emphasized in the variable-by-variable run-down below in section 4.4.1.

4.4.1 Standardization rules by variable

Production

The rule for production is perhaps the easiest to remember. Production of derived commodities is never standardized to the “production” variable—the production value of the primary commodity remains in this cell for the primary equivalent level. This is because the only commodity really being produced in the balance is the primary good—“production” of the remaining goods can instead be conceptualized as the conversion of the primary good into other products.

At the same time, FBS compilers should still standardize and aggregate production of derived goods (though not of co-products from the same transformation process) to ensure the production of derived goods is equal to the “food processing” variable in the primary commodity’s SUA.

Trade

In contrast to production, both imports and exports are *always* standardized, but *only* for the principal derived product (to avoid double-counting, as noted above) *or* for products that are not themselves part of another balance (i.e., wine trade would not be standardized back up into the grape balance). This standardization is achieved by dividing the import and export quantities for the derived commodities by their extraction rates, and then adding those standardized import and export values, respectively, together to arrive at a standardized, aggregated value of imports and exports.

In our example, that means that only imports and exports of rolled oats will be standardized and aggregated to avoid double-counting of the input quantity in the rolled oats production process, since bran of oats is a co-product of the transformation of oats into rolled oats.

We begin this process by recalling equation (2-9). To convert rolled oats to its primary equivalent, we must divide the quantity of rolled oats by its extraction rate. For imports, that looks like this:

$$Primary\ commodity\ equivalent = \frac{Quantity\ of\ derived\ product}{Extraction\ rate} \quad (2\text{-}9)$$

$$Primary\ commodity\ equivalent = \frac{14{,}074 \text{ MT rolled oats}}{\frac{0.65 \text{ MT rolled oats}}{1 \text{ MT oats}}}$$

$$Primary\ commodity\ equivalent = 21{,}652 \text{ MT oats equivalent}$$

For exports, the same calculation can be performed:

$$Primary\ commodity\ equivalent = \frac{Quantity\ of\ derived\ product}{Extraction\ rate} \quad (2\text{-}9)$$

$$Primary\ commodity\ equivalent = \frac{2{,}130 \text{ MT rolled oats}}{\frac{0.65 \text{ MT rolled oats}}{1 \text{ MT oats}}}$$

$$Primary\ commodity\ equivalent = 3{,}277 \text{ MT oats equivalent}$$

It is helpful then to include all standardized values in a single table in order to aggregate the respective primary equivalent import and export totals, as below in Table 4-15.

Table 4-15: Standardization of commodities to primary equivalent, and subsequent aggregation

	Quantity	*Extraction Rate*	*Primary Commodity Equivalent*
Imports			
Oats	188,219		188,219
Rolled oats	14,074	0.65	21,652
Oats equivalent total			**209,871**
Exports			
Oats	3,439		3,439
Rolled oats	2,130	0.65	3,277
Oats equivalent total			**6,716**

Stocks

In most cases, stocks are only estimated at the primary commodity level, which would not require any standardization. However, in cases where stocks are reported for derived commodities (such as concentrated orange juice, for example), they will need to be standardized. In this example for oats, because stocks are only estimated at the primary commodity level, no standardization is necessary here.

Food

Values for food are always standardized and aggregated.[74] This is particularly important because, for many commodities, no food use occurs at the primary commodity level, such that without standardization and aggregation, food values in the final balance would appear as zero. In this example for oats, the food estimate is standardized as above, by dividing by the extraction rate.

	$Primary\ commodity\ equivalent = \frac{Quantity\ of\ derived\ product}{Extraction\ rate}$	(2-9)
	$Primary\ commodity\ equivalent = \frac{\text{65,983 MT rolled oats}}{\frac{\text{0.65 MT rolled oats}}{\text{1 MT oats}}}$ $Primary\ commodity\ equivalent = \text{101,512 MT oats equivalent}$	

Food processing

In most cases, food processing should not be standardized and aggregated into the final balance for the primary equivalent. Instead, it is dropped altogether in order to avoid double-counting, as the *ultimate* use of quantities processed into food commodities is as food. The only exception is in cases where some processed product is standardized into another primary commodity equivalent of the FBS. For example, food processing of grapes into wine would not be standardized back up in to the grape balance, as there is a separate primary commodity balance for wine. In such cases, a quantity will remain in the grape balance under “food processing”.

In the oats example, food processing can be dropped from the balance at this point, as there are no derived products that become separate commodity balances.

Feed

Feed quantities will not be standardized and aggregated for many commodities, as co-products of transformation processes (such as brans, germs, or oilcakes) tend to be largely utilized as feed (if it is a useful exercise for countries, these quantities can be added together in a separate feed products balance). However, quantities estimated as feed for commodities that are the primary output of a transformation process should be standardized and aggregated.

[74] In the rare cases where a single transformation process produces more than one derived commodity used as food, compilers must choose which commodity to standardize and aggregate in order to avoid double-counting.

With respect to the oats example, this means that the feed quantity for oat bran will not be standardized and aggregated. Rather, the feed quantity of the primary commodity (oats) will remain as the feed quantity in the primary commodity equivalent balance.

Seed

Because seed only comes from the primary commodity, this value will remain unchanged in the FBS primary equivalent balance.

Net Tourist Food

As with food, quantities of food available for consumption by tourists must be standardized by dividing by the extraction rate, as below.

$$Primary\ commodity\ equivalent = \frac{Quantity\ of\ derived\ product}{Extraction\ rate} \quad (2\text{-}9)$$

$$Primary\ commodity\ equivalent = \frac{750 \text{ MT rolled oats}}{\frac{0.65 \text{ MT rolled oats}}{1 \text{ MT oats}}}$$

$$Primary\ commodity\ equivalent = 1{,}154 \text{ MT oats equivalent}$$

Industrial Use

Any quantities of industrial use will also need to be standardized, provided that they are for the primary output product of a given transformation—industrial use of co-products like brans or germs would not be standardized. In our example case, industrial use is only recorded at the primary commodity level, so no further calculation is needed.

Loss

Finally, quantities allocated to loss need to be standardized. As with industrial use, in our example, loss has only been recorded at the primary level, so no further calculation is needed.

4.4.2 Standardized and Aggregated table

The rules for each of the variables in the balance sheet were reviewed above. In our example case, the only quantities that need to be standardized and aggregated are those for imports, exports, food, and tourist food. Food processing is dropped at this stage in order to avoid double-counting of utilizations. For the remaining variables (stock change, feed, seed, industrial use, and loss), the quantities for the primary commodity (oats) will be entered into the (as yet unbalanced) primary commodity equivalent FBS table (Table 4-16).

Table 4-16: Unbalanced FBS table for oats commodity equivalent

Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*
Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940

4.5 Balancing

The balancing process is necessary to ensure that supply is equal to utilization in the FBS account after standardization and aggregation. As noted in the introduction to balancing given in section 2.4, the process of balancing primary commodity equivalent FBS balances is comprised of three steps: 1) calculating the imbalance from the supply = utilization identity, 2) distribute the imbalance, 3) check that balanced quantities are within any set bounded values, and rebalance if necessary. These steps are outlined below:

Step 1: Calculate the imbalance

This step is straightforward, and should be carried out regardless of the distribution mechanism that country-level FBS compilers choose. To do this calculation, it helps us recall equation (2-12).

$$\begin{aligned} Imbalance \ &= Production + Imports - Exports - \Delta Stocks - Food \\ &\quad - Food\ Processing - Feed - Seed - Tourist\ Food \\ &\quad - Industrial\ Use - Loss - Residual\ Use \end{aligned} \qquad (2\text{-}12)$$

We perform this simple calculation based on the values in the unbalanced FBS table (Table 4-16 above in our example case). Performing this calculation leads us to the imbalance noted on Line B below in Table 4-17.

Table 4-17: Calculating the imbalance in the unbalanced FBS table

Line	Product	Production (1)	Imports (2)	Exports (3)	Stock change (4)	Food (5)	Feed (6)	Seed (7)	Net Tourist Food (8)	Industrial Use (9)	Loss (10)	
A	Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6-A7-A8-A9-A10]											17,708

From here, country-level FBS compilers must choose which balancing approach they prefer.

Step 2: Distribute the Imbalance

While different strategies for distributing the imbalance in the primary commodity equivalent were outlined in section 2.4.1, these Guidelines will concentrate on the recommended "proportional error" approach detailed in section 2.4.1.1.

The first step in this process is using tolerance intervals and point estimates to quantify the error of each variable. Recall that tolerance intervals are assigned by variable *a priori* based on the relative confidence in the data (sample tolerance intervals can be found in section 3.4.2.3, but countries should designate their own intervals after considering the quality of their available data). In this instance, official data were available for production, imports, exports, and feed. As such, compilers in this country had a high degree of confidence in this data and assigned these variables tolerance intervals of zero. Data for food was imputed using a model, but because food availability should change little from year to year, a low tolerance level of 10 percent was assigned. Similarly, seed use was imputed, but as the imputation for seed implies a certain seeding rate, the confidence in the seed estimate should also be high. For this reason, a tolerance interval of 15 percent was assigned for seed. Data for stock changes, net tourist food, and loss were also imputed using models, but these quantities are much more likely to fluctuate. Consequently, compilers assigned each of these variables a tolerance interval of 30 percent. Finally, the data for industrial use were arrived at using expert estimation, so country-level compilers had little confidence in this estimate and assigned it a tolerance interval of 40 percent. These percentages are then added to the table in Line C (Table 4-18).

Table 4-18: Tolerance interval percentages assigned

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Stock change (4)*	*Food (5)*	*Feed (6)*	*Seed (7)*	*Net Tourist Food (8)*	*Industrial Use (9)*	*Loss (10)*	
A	Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6-A7-A8-A9-A10]											17,708
C	Tolerance interval (in %)	±0%	±0%	±0%	±30%	±10%	±0%	±15%	±30%	±40%	±30%	

Once the percentages have been added, the data in Line A can be multiplied by the percentages in Line C to arrive at quantified error estimates in Line D. These quantified errors are then summed to arrive at an aggregated error, calculated on Line E (Table 4-19).

Table 4-19: Errors quantified and aggregated error calculated

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Stock change (4)*	*Food (5)*	*Feed (6)*	*Seed (7)*	*Net Tourist Food (8)*	*Industrial Use (9)*	*Loss (10)*	
A	Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6-A7-A8-A9-A10]											17,708
C	Tolerance interval (in %)	±0%	±0%	±0%	±30%	±10%	±0%	±15%	±30%	±40%	±30%	
D	Error [D=A*C]	0.0	0.0	0.0	3,705.0	10,151.2	0.0	1,845.0	346.2	1,000.0	1,182.0	
E	Aggregated error [E=D1+D2+D3+D4+D5+D6+D7+D8+D9+D10]											18,229.4

From here, the error is distributed proportionally. In order to do so, the proportion of error must first be calculated. This is achieved by dividing the individual variable errors in Line D by the aggregated error estimate on Line E (Table 4-20).

Table 4-20: Proportion of aggregated error for each individual variable calculated

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Stock change (4)*	*Food (5)*	*Feed (6)*	*Seed (7)*	*Net Tourist Food (8)*	*Industrial Use (9)*	*Loss (10)*	
A	Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6-A7-A8-A9-A10]											17,708
C	Tolerance interval (in %)	±0%	±0%	±0%	±30%	±10%	±0%	±15%	±30%	±40%	±30%	

D	Error [D=A*C]	0.0	0.0	0.0	3,705.0	10,151.2	0.0	1,845.0	346.2	1,000.0	1,182.0	
E	Aggregated error [E=D1+D2+D3+D4+D5 +D6+D7+D8+D9+D10]											18,229.4
F	Proportion of aggregated error [F=D/E]	0.0%	0.0%	0.0%	20.3%	55.7%	0.0%	10.1%	1.9%	5.5%	6.5%	

Next, the quantity of adjustment for each variable is calculated by multiplying the proportion of aggregated error calculated in Line F by the equation's imbalance in Line B. Each of the unbalanced quantities from Line A are then adjusted by the quantities in Line G. Note here that the imbalance is positive. This means that there is more supply than there is demand. For this reason, the adjustments in all the demand variables (i.e., everything except production and imports) will be positive. Had there been any adjustments in supply variables, the adjustments there would be negative.

The other point to note here is that the imbalance in the equation is smaller than the aggregated error. FBS compilers will find that this is not always the case…sometimes the equation's imbalance will be much greater in magnitude than the aggregated error. This situation suggests that the bounds imposed through the tolerance intervals were too restrictive, and could indicate that one of the imputations (or even one of the official estimates) should have a larger tolerance interval. Unfortunately, there is no way of knowing exactly which variable is problematic. Such a situation should, however, be taken as a signal to FBS compilers that a closer examination of tolerance error percentages, and perhaps a reconsideration of them, may be warranted. In cases where the imbalance is larger than the aggregated error, FBS compilers should note that the adjustments will necessarily be larger than the estimated error.

In our case, however, the imbalance is less than the aggregated error, such that the adjustments will be lower than the estimated errors (compare Line G in Table 4-21 to Line D).

Table 4-21: Distributing the imbalance proportionally

Line	*Product*	*Production (1)*	*Imports (2)*	*Exports (3)*	*Stock change (4)*	*Food (5)*	*Feed (6)*	*Seed (7)*	*Net Tourist Food (8)*	*Industrial Use (9)*	*Loss (10)*	
A	Oats primary equivalent	131,259	209,871	6,716	12,350	101,512	182,950	12,300	1,154	2,500	3,940	
B	Imbalance for A [A=A1+A2-A3-A4-A5-A6-A7-A8-A9-A10]											17,708
C	Tolerance interval (in %)	±0%	±0%	±0%	±30%	±10%	±0%	±15%	±30%	±40%	±30%	
D	Error [D=A*C]	0.0	0.0	0.0	3,705.0	10,151.2	0.0	1,845.0	346.2	1,000.0	1,182.0	
E	Aggregated error [E=D1+D2+D3+D4+D5 +D6+D7+D8+D9+D10]											18,229.4
F	Proportion of aggregated error [F=D/E]	0.0%	0.0%	0.0%	20.3%	55.7%	0.0%	10.1%	1.9%	5.5%	6.5%	
G	Adjustment [G=B*F]	0.0	0.0	0.0	3,599.1	9,861.0	0.0	1,792.3	336.3	971.4	1,148.2	
H	Oats equivalent adjusted values [for (1) and (2), H=A-G, for remaining, H=A+G]	131,259.0	209,871.3	6,715.9	15,949.1	111,373.3	182,950.0	14,092.3	1,490.1	3,471.4	5,088.2	
I	Imbalance for H [I=H1+H2-H3-H4-H5-H6-H7-H8-H9-H10]											0.0

Step 3: Ensure that balanced quantities are within any set bounded values

This step serves as the final "reality check" on the now balanced quantities. This step will depend upon the bounds that FBS compilers have set in their analysis of each commodity's supply and demand situation. The most obvious check is that cumulative stocks are non-negative given the changes. Other hypothetical checks in our example situation could include things like ensuring that the balanced estimate for seed implies a reasonable seeding rate. In case any value is identified as outside of bounds, that value is set at the bound, assigned a zero tolerance interval, and the process is repeated.

4.6 Nutrient supplies and calorie estimates

Nutrient supplies are then added, for each of the SUA level commodities, based on SUA-level food estimates before standardization. However, if the food quantity of the FBS primary equivalent level was adjusted during balancing, then food quantities for all commodities in the account should first be scaled up by the same percentage. That is, a scaling factor should be calculated that compares the adjusted food value to the food value in the unbalanced identity. This scaling factor is simply the ratio of the adjusted food quantity to the food quantity before balancing, as below in equation (4-1).

$$Scaling\ Factor = \frac{Adjusted\ FBS\ Food\ Value}{Beginning\ FBS\ Food\ Value} \quad (4\text{-}1)$$

For our example on oats, then, the calculation would be:

$$Scaling\ Factor = \frac{Adjusted\ FBS\ Food\ Value}{Beginning\ FBS\ Food\ Value} \quad (4\text{-}1)$$

$$Scaling\ Factor = \frac{111{,}373.3}{101{,}512}$$

$$Scaling\ Factor = 1.09714$$

Then, once this scaling factor has been calculated, all food quantities for each commodity in the SUA should be multiplied by this scaling factor. In the oats example, since the final balanced primary equivalent-level FBS food quantity rose compared to the unbalanced quantity, the food quantity for rolled oats must first be scaled up before the quantity can be converted into its nutrient equivalents (Table 4-22).

Table 4-22: Food quantities scaled up based on balanced FBS

Product	*SUA Food Quantity (A)*	*Scaling Factor (B)*	*Scaled Food Quantity (C) (C=A*B)*
Rolled oats	65,983	1.09714	72,393

After the calculation of the scaled food quantity, then the nutrient conversion can proceed. Analysts should pay careful attention here to ensure that the units are correct. For example, nutrient tables may be published in kilocalories per 100 grams (as is the case with the FAO reference nutrient table), or even in kilojoules. Deriving a quantity for daily nutrient availability values is a simple conversion, whereby the volumes of food are multiplied by their nutritional unit values, and then divided by the number days in a year.

In addition, analysts should pay careful attention as to whether or not their nutrient conversion factors take into account inedible parts. If their nutrient factors are on the basis of only *edible* product weights, then the food quantities (which, recall, are expressed in gross product weight including both edible and non-edible parts) must first be converted to edible quantity of food through the application of a refuse factor. As the nutrient conversion factors published by the FAO Statistics Division (and utilized in this example) are calculated on the basis of gross weight (taking into account the portion of each commodity that is inedible), this step is not necessary here.

In our oats example, the nutrient table could be organized as below. Country-level FBS compilers may wish to compile it differently (using different units, for example), but this organization is intended to stress the importance of the units in the conversion process. First, the commodities for which food utilizations were recorded are added to the table—in this example, rolled oats was the sole commodity utilized for food, so it alone is added to the table (Table 4-23). Then the scaled up food quantities (calculated above in Table 4-22) are added. For ease of comparison, the quantities in MT are first converted to grams (Column 1 to Column 2). Again, this is because the nutrient values (included in the orange columns) are all in grams. To calculate a country's daily total availability for the different nutrients derived from each commodity, the value in Column 2 is then multiplied by the nutrient values in Columns 3 through 5 and divided by 365, resulting in the data in columns 6 through 8. Recall that these are aggregated, country-level estimates. Per capita estimates will be defined in the final step.

Table 4-23: Converting food quantities into nutrient values

Line	*Product*	*Quantity Food (MT) (1)*	*Quantity Food (g) (2)*	*kcal energy/g (3)*	*Protein/g (4)*	*Fat/g (5)*	*Energy (kcal/day) [A6=A2*A3/365] (6)*	*Protein (g/day) [A7=A2*A4/365] (7)*	*Fat (g/day) [A8=A2*A5/365] (8)*
A	Rolled oats	72,393	72,393,000,000	3.84	0.16	0.063	761,614,027	31,733,918	12,495,230

For many commodity trees, it is likely that several commodities in the tree will be consumed as food. Thus, after food quantities are converted into nutrient values, the next step is to add up total nutrients for the commodity tree. In our example case, a food quantity was only recorded for rolled oats. Therefore, the total energy, protein, and fat for the whole oats tree comes from rolled oats, as can be seen when Line B (total nutrients from the oat tree) is compared to Line A (nutrients from rolled oats alone) (Table 4-24).

Table 4-24: Nutrient values are summed

Line	*Product*	*Quantity Food (MT) (1)*	*Quantity Food (g) (2)*	*kcal energy/g (3)*	*Protein/ g (4)*	*Fat/g (5)*	*Energy (kcal/day) (6)*	*Protein (g/day) (7)*	*Fat (g/day) (8)*
A	Rolled oats	72,393	72,393,000,000	3.84	0.16	0.063	761,614,027	31,733,918	12,495,230

B	Total national nutrient availability for oats and products [B=sum of nutrients for all products used for food in the account]	-	-	-	-	-	761,614,027	31,733,918	12,495,230

4.7 Derive per capita estimates

The final step is to convert the national aggregate nutrient estimates into per capita equivalents. This is accomplished by dividing the national nutrient totals in Line B by population in Line C to arrive at per capita estimates of nutrient availability in Line D (Table 4-25).

Table 4-25: Per capita nutrients calculated

Line	*Product*	*Quantity Food (MT) (1)*	*Quantity Food (g) (2)*	*kcal energy/g (3)*	*Protein/g (4)*	*Fat/g (5)*	*Energy (kcal/day) (6)*	*Protein (g/day) (7)*	*Fat (g/day) (8)*
A	Rolled oats	72,393	72,393,000,000	3.84	0.16	0.063	761,614,027	31,733,918	12,495,230
B	Total national nutrient availability for oats and products [B=sum of nutrients for all products used for food in the account]	-	-	-	-	-	761,614,027	31,733,918	12,495,230
C	Population						38,360,000	38,360,000	38,360,000
D	Per capita average national nutrient availability for oats and products [D=B/C]						19.85	0.83	0.33

Once these nutrients are calculated, they can be added to the primary commodity equivalent supply and utilization table to arrive at the final food balance for oats and products (Table 4-26).

Table 4-26: Balanced FBS table for oats

	Domestic Supply				*Domestic Utilization*						*Per capita supply*		
Product	*Production*	*Imports*	*Exports*	*Stock change*	*Food*	*Feed*	*Seed*	*Net Tourist Food*	*Industrial Use*	*Loss*	*Energy (kcal/day)*	*Protein (g/day)*	*Fat (g/day)*
Oats and products	131,259	209,871	6,716	15,949	111,373	182,950	14,092	1,490	3,471	5,088	19.85	0.83	0.33

It should be noted that this is the table for just one primary commodity equivalent. The process outlined above would then need to be repeated for all food commodities, and then combined into one comprehensive, national FBS. When the lines for all commodities have been included, the per capita daily supplies of energy, protein, and fat for the individual commodities can then be added up to calculate total daily supplies. The total arrived at for energy is the daily dietary energy supply (DES).

4.8 Validation and troubleshooting infeasible solutions

In the course of compiling FBS and once the accounts are completed, FBS compilers should embark on a process of validating their estimates. These processes should be undertaken with the goal of addressing the following: are these estimates feasible? And if not, what is the best manner in which to correct this estimate to improve its feasibility? Validation processes will vary from country to country, but some of the most common checks are described below.

Very large changes in food availability/DES

As noted multiple times throughout these Guidelines, overall food availability (as expressed through the DES) should be fairly stable from year to year, likely not varying by more than 50 kcal, and very rarely by more than 100 kcal (most likely in cases of war, famine, or other crisis). Countries should analyze their final DES total and consider the result in the context of a time series of data. Feasibility may be judged in terms of an absolute threshold change or a percentage change from the previous year.

In addition to the overall DES, per capita calories for particular products or product groups can be a useful measure of feasibility in and of itself. Analysts should use their understanding of their particular country circumstances in this process, but a few suggestions include:

- The overall makeup of the DES by commodity category should change little from year to year. That is to say that the percentage of calories from different commodity groups is not likely to vary by more than a percentage point or two on an annual basis. If larger jumps are identified, then analysts should check the annual changes in the most important products in that basket first to pinpoint where revisions may be necessary. If, however, the annual jumps or declines are justified, analysts should make a note of this justification.
- Calories may change significantly for foods that are highly substitutable, but the overall calories level derived from substitute products should not change substantially. For instance, the total calories derived from vegetables should remain stable, but the calories derived from fresh green beans may fall by half while the calories sourced from green peas and carrots both rise.
- If FBS suggest that there was a large change in the food availability of a given good in a particular year, one way that analysts can verify the change is by looking at changes in consumer prices—if prices climbed dramatically, then a large reduction in food availability is more feasible (and vice versa).

Large, improbable percentage changes in any other variable from year to year

As with food availability, many of the other utilization variables are unlikely to experience huge changes from one year to the next, except in very particular circumstances. The magnitude of feasible annual percentage change will depend upon the circumstances of the country and the product, however, so it is key that FBS compilers strive to understand their country's market dynamics as holistically as possible. Country-level FBS compilers are advised to calculate year-over-year percentage changes in all supply and utilization variables and then assess those changes on a case-by-case basis.

Analysts should be advised that large annual percentage changes in balance sheet values may be completely valid. For example, while a doubling of production of a staple food like wheat is highly improbable from one year to the next, the doubling of production of a highly specialized product like a minor fruit crop may be possible (particularly in a small country). In the same vein, a doubling of the industrial utilization of a given commodity from one year to the next may appear suspect, but may also be feasible if a new utilization was found, or if a new processing facility was constructed.

The takeaway here should be that annual percentage changes are a useful indicator that something in the balance sheet *may be* incorrect, but they should not be interpreted as an absolute indicator that something *is* incorrect.

Identifying production of new commodities thanks to trade discrepancies

One of the balancing constraints noted in section 2.4.2 is the row constraint: production net of trade and stock changes must be positive. The rationale behind this constraint is obvious—a country cannot export more than they are producing, importing, and removing from stocks. This intuitive concept can be a useful way for countries to identify growing production of commodities that may not be included in annual production surveys (typically minor specialty crops). If no production is reported for a particular commodity and exports exceed imports, then that is an indication that production is occurring, and should either be surveyed, or else a production quantity should be imputed to cover the trade deficit.

FBS compilers should note that this constraint is commonly used to identify production of derived commodities in the absence of any information on production of derived commodities. For example, if a country grows tomatoes but then suddenly begins to export canned tomatoes, this is an indication that some of the fresh tomatoes are being processed into canned tomatoes.

The constraint can also be useful in identifying likely production of new commodities—particularly for new horticultural products grown exclusively for export markets.

No balanced solution possible given all constraints

Although not probable using the proportional imbalance balancing mechanism, the existence of constraints on specific variables opens the possibility to no solution. As an example, consider a country that measures all variables, save for stocks, but assumes that all the other values have zero tolerance intervals. After balancing, compilers note that the calculated withdrawals from stocks are larger than estimated stock levels—an impossibility. How can such a situation be resolved?

Examples such as these are an indication that the bounded values are too stringent. In the above example, a couple of scenarios are possible. First, it is possible that the estimated stock levels were incorrect, and there are sufficient stocks to permit the calculated withdrawal. Second, it is possible that the assumed tolerance intervals for the other variables was too stringent and needs to be relaxed for the equation to balance. This determination will need to be made at the discretion of the country-level FBS compilers.

4.9 Validation through working groups

In most countries, the majority of the work of compiling FBS will likely fall to a particular person, or a specific group within a designated agency. However, because the supply and demand situation for commodities is dynamic, it is recommended that the balance sheets for the major commodities be validated by the technical working group suggested in section 3.2. This process of validation through working group has various advantages that will contribute to the long-term accuracy and utility of the FBS compilation process. First, this group review provides FBS compilers with some additional pairs of eyes to help spot either data inconsistencies or infeasible solutions that may escape the notice of compilers who may have less expertise when it comes to the product in question. Second, the review of draft FBS by product experts ensures that FBS compilers are kept abreast of developments in the commodity, ensuring that any new uses are identified so that a strategy can be devised to properly account for these new uses within the FBS framework. Finally, the process of validating FBS through working groups can also facilitate greater buy-in to the overall FBS process from users and stakeholders. Allowing relevant groups to contribute to the process, voice their opinions, and understand how the various estimates are devised or where the data comes from helps to foster a sense of ownership amongst stakeholders. While a sense of ownership is valuable in and of itself, it can also benefit the FBS process by convincing relevant parties of the value in contributing data to better inform the exercise. Outside stakeholders may also be more likely to promote the final product if they have been able to contribute to the process.

4.10 Summary

This chapter has educated users about the process of constructing an FBS through the step-by-step working of a practical example. This example walked users through the filling of the SUA table, the balancing of SUA accounts for derived products, the processes of standardizing and aggregating the accounts, the balancing mechanism for the FBS primary-equivalent product, the calculation of nutrient supplies, and the derivation of per capita estimates. The chapter closed by offering some suggestions for basic FBS validation, while also encouraging that final FBS validation be undertaken by a technical working group. Now that users are comfortable with the process of producing FBS, Chapter 5 will offer some final considerations on data quality, data dissemination, and FBS interpretation.

5

Data Quality Considerations, Dissemination, and FBS Interpretation

5.1 Introduction

As stressed throughout these Guidelines, FBS are analytical datasets that strive to integrate, reconcile, and cross-validate data from multiple sources. This is a challenging undertaking, and is frequently plagued by either an absolute lack of data, or else the imperative to reconcile data of poor quality. Extensive text in these Guidelines has been devoted to the idea of data quality—that is, not every estimate is precise or reliable to the same degree. But there are additional dimensions to data quality that FBS compilers should consider, both to ensure the integrity of their FBS preparation process, and to facilitate the dissemination and interpretation of the final FBS dataset by users. This chapter covers these data quality considerations in brief before turning to recommendations on data dissemination, ending with some final notes intended to better facilitate interpretation of FBS data.

5.2 Quality Considerations

The "garbage-in, garbage-out" philosophy is an oft-repeated caution for those working in the field of data analysis, and the mantra holds true for the process of FBS compilation as well. But it is also true that good quality input data alone is not sufficient to ensure that a given statistical output will be successful. The concept of "data quality" has as much to do with the processes devoted to data production as it does with the final product itself. In this regard, FBS compilers should conduct their work keeping the following five quality dimensions in mind[75]:

- Relevance
- Accuracy and reliability
- Timeliness and punctuality
- Coherence and comparability

[75] These five dimensions of quality come from the FAO statistical quality assurance framework, but are equally relevant to country-level agricultural statistics systems. The framework in its entirety is available here: http://www.fao.org/docrep/019/i3664e/i3664e.pdf.

- Accessibility and clarity

The specific manner in which these five dimensions relate to the compilation of FBS is elaborated below:

Relevance

FBS should not be compiled "just because." National-level FBS compilers should begin the process of FBS compilation with some goal for how the data will be used and analyzed by stakeholders. In order to determine the needs of stakeholders, initial consultations with users may be held, or user surveys may be conducted once the first year of data has been produced and distributed.

It then follows that FBS should be compiled with the intention of meeting these identified needs of current and future users. In the context of the FBS, this may mean covering only the commodities that are most relevant to stakeholders (say, the top 25 most-consumed products instead of all products). This may also mean computing certain indicators from the data to ease interpretation.

Accuracy and Reliability

In the realm of data quality, "accuracy" refers to how close an estimate is to its true value (which can be as a consequence of either variance or bias), while "reliability" instead focuses on the magnitude of revisions, or how close initially-reported values are to subsequent/final data. Both concepts are relevant to FBS data, but the concept of accuracy deserves special emphasis here. One of the primary motivations for the updating of the FBS methodology within these Guidelines was a desire to make the accuracy of individual estimates more transparent, and to take advantage of available information on the perceived accuracy of a given point estimate to balance the supply = utilization identity in a way that eliminates accumulated error in a single balancer. As such, with respect to accuracy, the two most relevant suggestions of these Guidelines are that countries 1) measure/approximate, document, and publish error estimates, and 2) develop and institute a data flag system that succinctly communicates information about the source of the data (and hence, communicate some information about implied accuracy) to users. Recall from section 3.4.2.2 that data should be published with flags indicating the data source. Although it may not be feasible to also communicate the tolerance interval of the estimate in the table, this information should be published somewhere—either in footnotes to the table, or in the accompanying metadata that describes the processes of compiling the FBS. How this is communicated is at the discretion of country-level FBS compilers, but two examples are provided below.

The first suggested layout is the addition of a column after each variable denoting the flag. The flag should then be explained—either within the table notes or as additional cells within the table itself. In the example below in Table 5-1, the notes are included below the table.

Table 5-1: Sample presentation 1 of data table including flags

Year	*Product*	*Production*	*Flag*	*Imports*	*Flag*	*Exports*	*Flag*	*Food*	*Flag*	*Loss*	*Flag*	*Energy (kcal/day)*	*Protein (g/day)*	*Fat (g/day)*
2008	Onion	2,000	T	58,000		1,000		72,000	I	6,000	I	38	9	4

NOTE: Flags indicate the source of the data, as follows:

“ ” indicates that the data come from an official source.
“T” indicates that the data come from a semi-official source.
“I” indicates that the data are an imputed value.

An alternative presentation of the same data does not present the flag in columns. Rather, it refers the user to table footnotes that provide a further explanation on the data source. In this presentation, it is also feasible to include information on the tolerance interval assigned to each variable (Table 5-2).

Table 5-2: Sample presentation 2 of data table detailing sources and tolerance intervals in table footnotes

Year	*Product*	*Production[a]*	*Imports[b]*	*Exports[b]*	*Food[c]*	*Loss[d]*	*Energy (kcal/day)*	*Protein (g/day)*	*Fat (g/day)*
2008	Onion	2,000	58,000	1,000	72,000	6,000	38	9	4

[a] Data come from a semi-official source. This estimate has an assigned tolerance interval of ±10%.
[b] Data come from an official source. This estimate has an assigned tolerance interval of ±0%.
[c] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[d] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.

Of course there are a myriad of other ways in which this data can be presented. The key takeaway here is that whatever presentation is chosen *should* include data flags or indications of data sources, and may also communicate assigned tolerance intervals in order to better convey data accuracy to users. It bears repeating that if tolerance intervals are not communicated to users in data tables, further information on them should be included in the table’s accompanying metadata.

While accuracy refers to the closeness of an estimate to its true value, reliability instead refers to how close an initial estimate is to subsequent estimates. This is relevant to FBS because compilers should always be open to updating their FBS as new information becomes available—perhaps trade data is revised, or maybe a country begins a new program of measurement for loss and finds that estimates in previous years were much too high, necessitating back-year revisions. In all cases, FBS compilers should compare the initial estimates to subsequent ones and analyze their statistical processes to see if initial estimates can be improved. In addition, it is important that data producers are transparent about revision policies and timelines. At a minimum, users should be notified of revisions (and, if relevant, the justification for the revisions as well).

Timeliness and Punctuality

In the context of data dissemination, “timeliness” indicates how long after the reference year a dataset is published, while “punctuality” refers to releasing the data on a previously indicated date.

When publishing FBS data, compilers typically face a trade-off between timeliness and accuracy: on the one hand, there is a desire to release data to users as soon as possible, but doing so may mean that not all data has had a chance to be properly validated. In the context of the FBS, much of the underlying data is produced on a lag. As an example, official production data for 2015 may not be released until 2017. Even then, that data may be revised in 2018 or 2019 as more information becomes available. In these instances, the choice becomes whether to wait for the ostensibly more accurate final data at the risk of the data becoming irrelevant to users, or release more timely data that may be subject to large revisions.

In order to best meet data user needs, it is suggested that country-level FBS compilers shoot for releasing their preliminary datasets ideally the year after the FBS reference year. However, this does not preclude compilers from revising datasets should new information become available. In that case, preliminary data can be labeled as such to differentiate it from finalized estimates.

With respect to punctuality, it is recommended that compilers publish an expect data of delivery on their agency's external website, and then strive to deliver the product by that date. Workflow planning can assist in achieving this goal.

Coherence and Comparability

The concepts of coherence and comparability are highly relevant to FBS compilation, with "coherence" referring to the ability of statistical outputs to be combined with other data or utilized for various purposes, while "comparability" refers to the extent to which data is comparable between areas or across time.

First focusing on coherence, the underlying structure of the FBS data makes it very likely that this data will be coherent with other domains. In fact, the data contained within FBS will in most cases be sourced from a variety of domains in the first place—as long as data sources and characteristics are properly documented, users should find that FBS estimates are coherent with most other agricultural datasets. Of course, this will only be the case in countries that produce unique datasets for the different supply and utilization elements. In instances where a country produces multiple production estimates, for example, FBS production estimates will likely be based on only one of the sources, and thus will not be coherent with the other. In these cases, FBS compilers should justify why one source was preferred over another.

With respect to comparability, as emphasized in these Guidelines, the nature of FBS compilation is that data from various domains is identified and combined in such a way as to make it comparable. Recall from section 3.4 that within the initial data assessment that precludes the process of putting the FBS together, analyst must first ensure that data is comparable in three key dimensions:

- Product comparability: Data for each one of the variables in the balance must refer to the same product. This process can be greatly aided by the use of numerical product classifications such as CPC.

- Unit comparability: Data for all of the variables should be elaborated in the same unit. For most countries, this is MT. Compilers should use internationally-recognized conversion factors if any data need to be transformed from one unit into the unit in which the balance is being compiled.

- Temporal comparability: All data should refer to the same reference period, whether or not this is a calendar year or a marketing year.

Even for the most diligent FBS compiler, full data comparability may not be possible. In these cases, at the very least, these differences should be documented so that users are aware of the data's limitations.

Accessibility and Clarity

"Accessibility" can be defined as the ease with which users are able to obtain the data in question, while "clarity" refers to the availability of adequate documentation that explains the dataset to the user. Some additional guidance on data dissemination and accessibility is provided below in section 5.3, so the focus here will be on clarity.

Clarity covers all aspects of what users need to know to understand the data. This includes metadata, data quality indicators, and advice on data interpretation. When disseminated to a general audience, it is recommended that the data be accompanied by the following:

- Metadata detailing various aspects of the dataset, including units, time period covered, classifications, and underlying data sources (for ease of reference, a separate discussion on metadata is included below in section 5.3.3).

- Quality reporting detailing how much of the data has been imputed versus comes from official sources. Essentially, this reporting should allow users to understand the potential limitations of the data in a transparent way, but also provide compilers themselves with some indication of how the dataset can be improved in future.

- Public documentation of the general FBS compilation methodology utilized should be posted alongside the dataset to facilitate user understanding of how the dataset was compiled. While it is not necessary to externally publish the cell-by-cell documentation of any edits or revisions, it is considered best practice to *internally* keep very detailed records of this sort. This document can be referred to if there is any question about a particular estimate, or in the case that new information surfaces or an improved methodology is developed to better estimate a given value in future.

5.3 Dissemination

5.3.1 The case for wider dissemination of FBS data

As noted elsewhere in these Guidelines, FBS provide countries with a unique and valuable tool for analysis and policymaking. However, such analysis need not take place solely inside the confines of the group that compiles the FBS. Indeed, the dataset of the FBS should be considered a valuable public resource. For this reason, country-level compilers should go beyond merely compiling FBS and plan to disseminate this data to the public. FBS datasets should enter into the pantheon of datasets likely already published on either NSO or Ministry of Agriculture websites (such as datasets on agricultural production and trade). If the country produces any sort of annual agricultural statistical abstract, the FBS data tables should also be considered for inclusion in that publication.

While posting the datasets to an official website is an excellent first step, country-level FBS compilers are encouraged to go beyond publishing the data and provide some basic data analysis and context in order to better inform both policymakers and laypeople. If the FBS are draft by a purely statistical unit, this exercise may require first establishing a linkage or coordination mechanism between the statistical group and other researchers or analysts within the country's Ministry of Agriculture, NSO, or external research institutions.

Even the most basic accompanying explanatory text can be useful. For example, if wheat imports were shown to fall dramatically from one year to the next, some analysis on why that occurred might be helpful to users. To carry this example further, if calories from wheat-derived goods were to fall as a result of the contraction in imports, it may be useful to point out that calories from rice (another staple cereal good) increased in the same year, indicating that consumers substituted rice for wheat to maintain a stable overall cereal consumption level from year to year.

Particularly if carried out in conjunction with analytical units, the drafting of these types of analytical reports should be relatively straightforward. Moreover, the potential benefits of doing so are numerous, including increased visibility of the data product, increased literacy of the data product amongst all users, and increased demand for the data product as users in both academia and the general public become accustomed to the types of analyses that can be undertaken using FBS data.

5.3.2 Suggested presentation

FBS data can be presented in any number of manners (dependent upon the policy and data priorities of the country) because such a wealth of data is contained within the FBS. However, at least two presentations are suggested: data tables and data visualizations.

With respect to data tables, information can be presented in a number of layouts, but two of the most common are by year and by commodity. Since one of the primary objectives of FBS compilation is to demonstrate the complete dietary picture of a country at a given period in time, the first data table layout that compilers should consider presenting is the single-year portrait, whereby each primary commodity equivalent is displayed as a separate line in one comprehensive table (Table 5-3). It is suggested that on the first line of the table, the sum of total nutrient levels from all foods be displayed. Compilers may also choose to display certain aggregates in their tables, such as cereals, tubers, fruits, or meat. Compilers may also consider including an additional data flag or note to indicate where data has been standardized or aggregated.

Table 5-3: Sample table layout of FBS data organized by year

		Domestic Supply				*Domestic Utilization*				*Per capita supply*		
Year	*Product*	*Production*[a]	*Imports*[b]	*Exports*[b]	*Stock change*[c]	*Food*[d]	*Feed*[e]	*Seed*[f]	*Loss*[g]	*Energy (kcal/day)*	*Protein (g/day)*	*Fat (g/day)*
2007	Total All Foods									2863	65	72
2007	Maize and products	15,000	65,000	0	0	71,000	3,000	1,000	5,000	38	9	4
2007	Potatoes and products	0	23,000	1,000	-6,000	27,000	0	0	1,000	14	1	0
2007	Sunflower seed Oil	0	17,000	0	3,000	14,000	0	0	0	7	0	20
2007	Tomatoes and products	0	11,000	0	0	11,000	0	0	0	3	0	0
2007	Bananas	0	6,000	0	0	6,000	0	0	0	5	0	0
2007	Milk excluding butter	113,000	86,000	0	-7,000	172,000	19,000	0	8,000	144	8	7
2007	(Etc.)	-	-	-	-	-	-	-	-	2652	47	41

NOTE: Data for all commodity groups represents standardized and aggregated values of commodities derived from the indicated primary commodity. Further information on commodity trees can be found in the metadata.

[a] Data come from an official source. This estimate has an assigned tolerance interval of ±0%.
[b] Data come from an official source. This estimate has an assigned tolerance interval of ±0%.
[c] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[d] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[e] Data come from a semi-official source. This estimate has an assigned tolerance interval of ±10%.
[f] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[g] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.

While the data tables by year inform users about the complete dietary picture (aside from supplying the snapshot of supply and utilization for each commodity in a single year), the table layout of data by commodity allows users to analyze the time series to compare how the different aspects of supply and demand have moved over a given number of years. A sample table layout of data organized by commodity can be seen below in Table 5-4.

Table 5-4: Sample table layout of FBS data organized by commodity

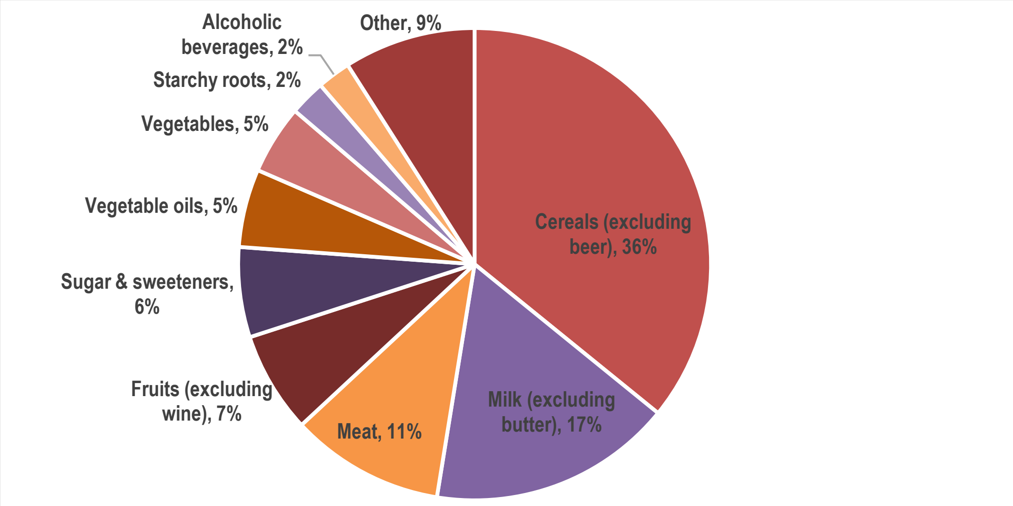
		Domestic Supply				*Domestic Utilization*				*Per capita supply*		
Year	*Product*	*Production[a]*	*Imports[b]*	*Exports[b]*	*Stock change[c]*	*Food[d]*	*Feed[e]*	*Seed[f]*	*Loss[g]*	*Energy (kcal/day)*	*Protein (g/day)*	*Fat (g/day)*
2008	Maize and products	2,000	58,000	1,000	-23,000	72,000	3,000	1,000	6,000	38	9	4
2009	Maize and products	9,000	76,000	0	5,000	69,000	4,000	2,000	5,000	36	8	3
2010	Maize and products	12,000	75,000	4,000	-3,000	74,000	3,000	2,000	7,000	38	9	4
2011	Maize and products	16,000	87,000	13,000	9,000	68,000	3,000	2,000	8,000	35	8	3

NOTE: Data for all commodity groups represents standardized and aggregated values of commodities derived from the indicated primary commodity. Further information on commodity trees can be found in the metadata.
[a] Data come from an official source. This estimate has an assigned tolerance interval of ±0%.
[b] Data come from an official source. This estimate has an assigned tolerance interval of ±0%.
[c] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[d] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[e] Data come from a semi-official source. This estimate has an assigned tolerance interval of ±10%.
[f] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.
[g] Data are an imputed value. This estimate has an assigned tolerance interval of ±25%.

It should also be noted that the format suggestion here is to publish only the FBS primary-commodity equivalent accounts. If countries wish to increase the level of detail available to users, they may consider publishing the more detailed SUA-level accounts as well. However, this should only be done if countries have explicitly outlined the methodology by which SUAs are standardized and aggregated to the primary-equivalent level in order to prevent confusion by users.

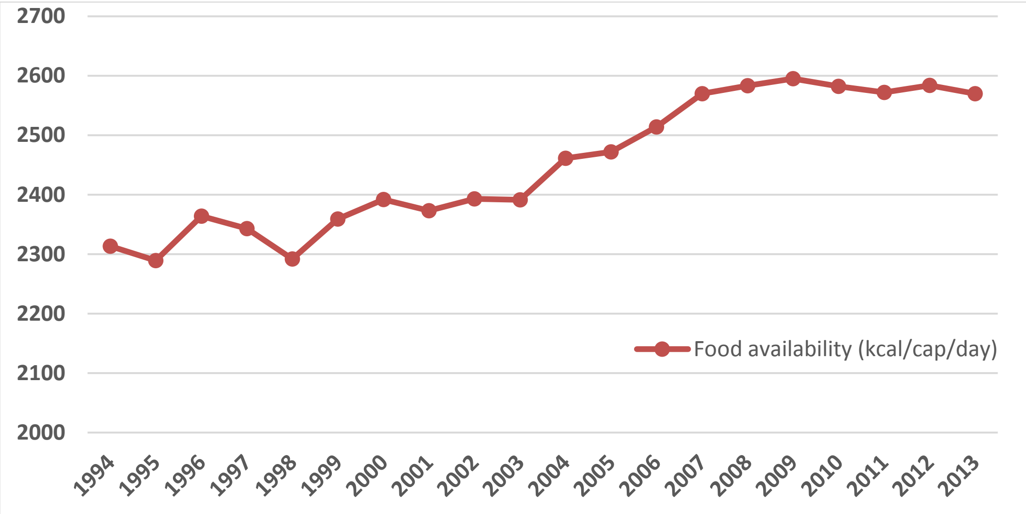
Data visualizations, in the form of graphs or charts, are another option for data presentation. The advantage of such visualizations are that they can communicate a lot of information to a user in a very straightforward manner. As above, visualizations can be used to describe data at a given point in time, or else they can illustrate changes across time. For example, in addition to displaying a table that lists the per capita energy supply from each commodity group, a pie chart can be used to convey the information, as below in Figure 5-1.

Figure 5-1: Sample visualization of FBS data, illustrating dietary composition by commodity group in a given year



Illustrating changes in data across time is another possibility for data visualizations, as they can allow users to better understand the overall trend behind any given variable. While these graphics can be published for any variable in the balance sheet, given the emphasis placed on the DES for policy formation and analysis, a line graph of this variable is an obvious choice, as below in Figure 5-2.

Figure 5-2: Sample visualization of FBS data, illustrating changing DES from 1994 to 2013



5.3.3 Metadata

Metadata is nothing more than underlying information that helps the user to better understand a given dataset. For every dataset produced, it is essential that it be accompanied by metadata so that users know exactly the underlying concepts and processes that went into the production of said data. This includes definitions of variables or commodities, clarification on units of measure, definition of the reference period, a listing of the underlying data sources, an explanation of the methodology behind the dataset's compilation, and some indication of data quality. The Joint UNECE/Eurostat/OECD Work Session on Statistical Metadata (METIS) has produced a Common Metadata Framework (including publications on "Statistical Metadata in a Corporate Context" and "Metadata Concepts, Standards, Models and Registries") that countries may find helpful as they seek to establish and implement their own metadata frameworks according to international best practices.[76]

In the context of FBS, this means indicating to users what commodity classification is used, how the different supply and utilization variables are defined (for example, does production exclude backyard production), some discussion of the underlying methodology, a disclosure of the sources for the different data components, a list of the assumptions behind extraction rates and processing shares, and an assessment of the quality of the data (which can be based on flags, for example). In some cases, it may be sufficient to provide a link to a background document detailing the methodology under which the data was produced.

All of the datasets available on FAOSTAT are published along with their metadata. These metadata can serve as a template for country-level FBS compilers who are not sure about exactly what kinds of detail to include when publishing their own metadata.[77]

5.4 Interpretation

While FBS data can be used in numerous applications (including econometric studies, trend analysis, investigations of dietary content, and nutritional adequacy analysis), the data should be understood for what they are—an analytical dataset that helps to capture a holistic snapshot of food supply and utilization for any one country at a given point in time. As such, in order to facilitate the accurate interpretation of FBS, several of their characteristics bear repeating.

Expected values, not point estimates

FBS are useful for capturing general trends in food availability, both in the aggregate and at the individual commodity level. However, because input data for each variable in the commodity balance will have been estimated with a certain margin of error, it is not correct to treat the derived estimates for calories per capita per day for an individual commodity (not to mention the total DES) as a point estimate. In reality, each of these derived estimates is an expected value as well, with some unknown error distribution. So while a country's FBS may estimate per capita availability of carrots at 9 calories, for example, the more accurate interpretation may be that availability is likely somewhere between 7 and 11 calories per person. This does not make this estimate of 9 calories bad, inaccurate, or useless—the estimate is still useful when compared to likely values of food availability over the previous years (to track availability trends over time), or in comparison to other products within the country's balance sheet (i.e., per capita availability of carrots is higher than per capita availability of green beans, which for the same country was estimated at 3 calories per capita). The same can be said of the overall DES—DES estimates should be understood as likely values, but not taken as exact values.

[76] All of these documents are available from UNECE's website, at: http://www1.unece.org/stat/platform/display/metis/The+Common+Metadata+Framework.
[77] See, for example, metadata for the crops production dataset, available at: http://www.fao.org/faostat/en/#data/QC/metadata.

At the same time, if one assumes that error distributions do not change significantly from one year to the next, then basing analyses on *changes* in availability (comparing one year to the previous year) should reduce the effect of any bias in measurement. In other words, looking at the change in variables can reduce the effect of systematic errors on interpretation of FBS estimates.

Measurement of apparent consumption

In contrast to household surveys which specifically measure the consumption of a good, food balance sheets instead measure apparent consumption. In laymen's terms, this means the amount of food that was *available* for consumption, whether it was consumed or not. As such, DES estimates should be understood not as a precise value of per capita food intake, but rather the amount of food available for human consumption within a country on a per capita basis. There are many reasons why the DES may not be equivalent to average levels of effective consumption. First, balance sheets don't take into account distributional differences in consumption (i.e., the wealthy in a country are likely to consume more than those in poverty). Although a certain amount of food may be considered to be "available" for consumption by all in a food balance sheet setting, in reality only a small segment of a country may have economic access to that food. Second, balance sheets do not take into consideration the spatial distribution of food within a country. In cases where most production of a given food item takes place in one part of the country but the bulk of consumers are elsewhere and don't have physical access to said food item, balance sheets will still show that said food product is "available" to the average person. Last, FBS estimates for food availability are assumed to be calculated at the retail level. This means that food waste at both the retail and consumer level are contained within the estimate of food availability. In countries with substantial consumer food waste problems, this means that using DES as a proxy for effective consumption would lead to a large overestimate in the amount of calories consumed by the average citizen.

Context

Barring war, disease, or natural disaster, overall consumption (not to mention consumption of staple foods and dietary share sourced from a given food group) is likely to change little from year to year. However, that does not mean that large year-to-year swings won't be seen in particular food items. While the FBS framework may provide little information about what caused a change in availability for a particular food, it does provide users with some clues to how both countries and consumers compensated for that change. For example, consider that Country A is a mid-level wheat producer, whose wheat crop is devastated in one year by a late freeze. This fact in isolation sounds extremely dire, and would certainly make an eye-catching headline ("Domestic wheat crop destroyed!"). But because the FBS framework brings together additional information, the damage to the wheat crop is not the end of the story. The country could increase wheat imports to compensate for the crop loss, or perhaps make a withdrawal from stocks to insure that domestic supplies remained unchanged. Barring that, it is possible that consumers switch to eating more rice in the face of higher wheat prices. In each one of these scenarios, it is completely possible that overall dietary availability will remain unchanged for this country, even in the face of this poor harvest.

It is this context—the ability to compare different variables, years, and commodities in order to draw some conclusions about the overall situation—that makes FBS such a powerful tool. While this context may not be so straightforward to the novice FBS user, with practice, FBS can be used to underpin the narrative for analysis of virtually any agrifood market.

5.5 Summary

This chapter has provided FBS compilers with some additional content relevant for countries once the FBS have been finalized—namely, considerations for data quality, dissemination, and interpretation. In ensuring that quality data are produced, compilers should consider the five aspects of data quality: relevance, accuracy and reliability, timeliness and punctuality, coherence and comparability, and accessibility and clarity. It is also suggested that countries disseminate their data for wider public consumption after it has been produced. To that end, a few different data presentations have been suggested. The chapter closed with some final thoughts for interpretation of FBS data that will help both compilers and users to appropriately utilize FBS data for policy analysis.

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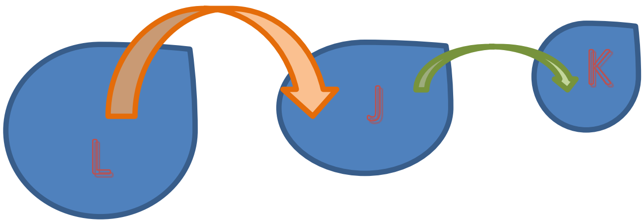
Appendix 1: Tourist Food

The estimation of tourist food begins with a simple calculation of the number of visitor days, *N*, for travelers originating from country *l* and visiting country *j*. To represent this flow of visitors traveling from country *l* to country *j*, the notation N_{lj} is used—note that the first subscript indicates the origin country and the second subscript indicates the destination country. Visitors to country *j* include both day visitors and overnight visitors, and these visits must be standardized to give us a total number of visitor days. To do so, the number of day visitors from *l* to *j*, N_{Dlj}, is added to the number of overnight visitors from *l* to *j*, N_{Olj}, multiplied by the average number of days an overnight visitor stayed, $\bar{D}$, as below in equation (6-1).

$$N_{lj} = N_{Dlj} + N_{Olj} * \bar{D} \tag{6-1}$$

Now that the convention of the notation has been introduced, a graphical representation of visitor flows better illustrates the conceptual framework of the imputation approach (Figure 6-1). Consider that the goal is to estimate net tourist food for country *j*. Every year, thousands of visitors travel from country *l* visit country *j*. These flows are denoted as N_{lj}—that is, the number of visitor-days for those traveling from country *l* to country *j*. In Figure 6-1, these flows are represented by the large orange arrow. At the same time, hundreds of country *j*'s residents travel abroad as well to visit country *k*. These flows can be denoted as N_{jk}, the number of visitor-days for residents of country *j* traveling to country *k*, with these flows represented by the small green arrow.

Figure 6-1: Simplified representation of net visitors to Country J



In this three-country scenario, for any individual commodity *i*, net tourist food for country *j* ($NetTF_{ij}$) can be represented as the amount of food (in MT) that is available for consumption in country *j* by incoming visitors from *l* to *j*, $Food_{ilj}$, minus the amount of food available for consumption by residents of country *j* that are instead visiting country *k*, $Food_{ijk}$ (equation (6-2)).

$$NetTF_{ij} = Food_{ilj} - Food_{ijk} \tag{6-2}$$

The amounts of food available for consumption by visitors in MT ($Food_{ilj}$ for incoming visitors and $Food_{ijk}$ for outgoing travelers) is calculated as the product of the amount of visitor-days *N* (as defined above in equation (6-1)) and the number of calories available for consumption daily, divided by the amount of calories per MT for commodity *i*. At this point, however, some intuitive assumptions about the quantities and dietary patterns of visitors should be introduced. Visitors are limited in their food choices to what is on offer locally. Although there are certainly instances where local restaurants cater to visitors by offering foods from the visitor's country of origin, it is assumed to be more likely that visitors follow the local dietary pattern (as a stark example to illustrate this concept, Mexican visitors to Italy are more likely to consume pizza than tacos).

At the same time, visitors are likely to consume the same overall amount of food that they would eat at home. To see why this is the case, consider this exaggerated illustration. Imagine a tourist from a very wealthy country (with a high daily DES of 3500 kcal/day) visiting a poor country (with lower DES estimated at 2000 kcal/day). Although this tourist may consume the foods of the local diet, they are not likely to reduce their consumption by nearly half to fully adapt to the local diet. Instead, we assume that they will eat local foods, but at a scale that accounts for their own typical daily caloric consumption. Keeping in mind the number of visitors, the dietary pattern in the destination country, the level of food availability in the origin country, and the amount of calories per MT, total food availability in MT of commodity *i* for visitors from country *l* to country *j*, $Food_{ilj}$, can be written as:

$$Food_{ilj} = \frac{\left[N_{lj} * \left(f_{ij} * \frac{\sum_i f_{il}}{\sum_i f_{ij}}\right)\right]}{\frac{cal_i}{MT}} \quad (6\text{-}3)$$

Where N_{lj} is the number of visitor-days for visitors traveling from country *l* to country *j*, f_{ij} represents the amount of calories of commodity *i* available for consumption in country *j*, the term $\frac{\sum_i f_{il}}{\sum_i f_{ij}}$ is the relative amount of total historical caloric availability[78] in country *l* compared to country *j*, and $\frac{cal_i}{MT}$ is the number of calories contained in one MT of commodity *i*. This adjustment of calories per unit is needed to convert the quantity from an estimate in calories to an estimate in weight needed for the SUA account for commodity *i*.

Building on the above example of the relative consumption of a wealthy country and a poor country for illustrative purposes, consider the following scenario. FBS compilers in country *j* are estimating inbound tourist consumption of beer of barley. Let's assume that country *j* is the relatively poorer country with daily DES of 2,000 kcal/cap/day (so, total daily caloric availability *f* for commodity *i*, summed over all commodities, or $\sum_i f_{ij}$), and country *l* is the wealthy country where DES ($\sum_i f_{il}$) is 3,500 kcal/cap/day. Tourists from country *l* spend 50,000 tourist-days in country *j* in the reference period. In addition, in country *j*, daily food availability of beer of barley, *f,* is 25 kcal/cap/day, and consulting a calorie conversion table, they find that there are approximately 430 calories per kilogram of beer of barley—equivalent to 430,000 calories per MT of beer of barley. Using this information, daily calories of beer of barley available for consumption by visitors from country *l* to country *j* can be imputed by performing the following calculation, according to (6-3).

$$Food_{beerlj} = \frac{\left[N_{lj} * \left(f_{beerj} * \frac{\sum_i f_{il}}{\sum_i f_{ij}}\right)\right]}{\frac{cal_{beer}}{MT}} \quad (6\text{-}3)$$

$$Food_{beerlj} = \frac{\left[50{,}000 * \left(25 * \frac{3500}{2000}\right)\right] calories}{430{,}000\, \frac{calories}{MT}}$$

[78] Country-level analysts should define for themselves what "historical caloric availability" means, but two suggests are 1) level of caloric availability in the previous year, or 2) average caloric availability over the previous three years.

$$Food_{beerlj} = 5.09 \text{ MT}$$

If countries are unable to access information on total food availability for visitors differentiated by country in order to calculate food as above in (6-3), then a simplification can be substituted. In these cases, the issue is that calories cannot be scaled appropriately based on the relative overall DES for visitors from each country. As such, the simplification here is that the scaling term can be dropped, and compilers can assume that visitors consume the same amount of the commodity as do residents. Depending upon the country and the relative country of origin of visitors, dropping this scaling may underestimate tourist consumption in some cases and overestimate it in others.

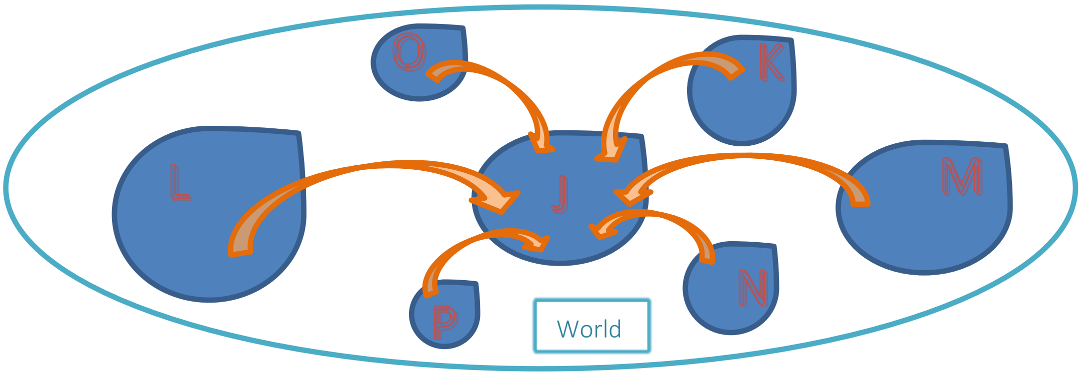
$$Food_{ilj} = \frac{(N_{lj} * f_{ij})}{\frac{cal_i}{MT}} \quad (6\text{-}4)$$

For outbound travelers, no scaling is necessary either, as the purpose of accounting for outbound travelers is to subtract what they would have eaten at home…not to detail exactly what they will eat while abroad. So similar to the above simplification, for outbound travelers the amount of calories of commodity i available for consumption per day in country j, f_{ij}, is simply multiplied by the number of visitor-days for travelers leaving country j, N_{jk}, and this number of total calories is then converted into a quantity in MT by dividing by the relevant nutrient factor, $\frac{cal_i}{MT}$, represented below in equation (6-5).

$$Food_{ijk} = \frac{(N_{jk} * f_{ij})}{\frac{cal_i}{MT}} \quad (6\text{-}5)$$

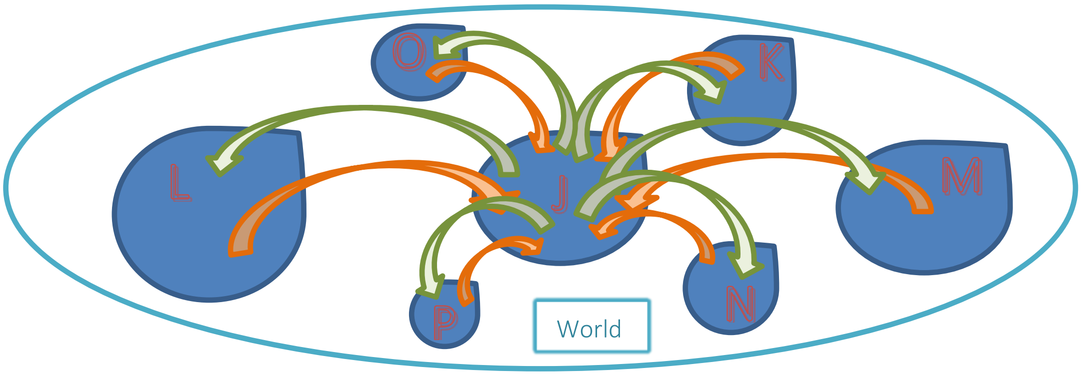
This simplified illustration hopefully aids in the understanding of how tourist food is calculated for visitors from a single country. However, in reality, we know that visitors are flowing into country j from many countries. In fact, they are potentially coming from every country in the world, except country j itself. These multiple inbound visitor flows are represented by the orange arrows below, in Figure 6-2.

Figure 6-2: Representation of inbound visitor flows to country J



At the same time that country *j* is receiving visitors from the rest of the countries in the world, it is also potentially sending visitors out to these same countries. So in comprehensively representing net tourism, country-level FBS compilers must account for multiple inbound visitor flows (orange arrows), and multiple outbound traveler flows (green arrows), as represented below in Figure 6-3.

Figure 6-3: Comprehensive representation of net tourism flows for country J



The approach required then, is to take the intuitive single country model presented in equation (6-2), and expand upon it by summing up all the individual food quantities from the unique bilateral visitor flows. We can represent this aggregation using summation notation, combining equations (6-2), (6-3), and (6-5) into a single model, described below in equation (6-6).

$$NetTC_{ij} = \underbrace{\frac{\sum_{l=1,l\neq j}^{x}\left[N_{lj} * \left(f_{ij} * \frac{\sum_i f_{il}}{\sum_i f_{ij}}\right)\right]}{\frac{cal_i}{MT}}}_{\text{Food consumed by incoming visitors}} - \underbrace{\frac{\left(\sum_{k=1,k\neq j}^{x} N_{jk}\right) * f_{ij}}{\frac{cal_i}{MT}}}_{\text{Food consumed by outgoing visitors}} \qquad (6\text{-}6)$$

The only additions to this notation are the country summation terms, $\sum_{l=1,l\neq j}^{x}[\,]$ and $\sum_{k=1,k\neq j}^{x}[\,]$, indicating that the calculation should be performed for all countries in set *x* (in this case, the world) beginning with country *l* but excluding country *j* in the first case, and beginning with country *k* and excluding country *j* in the second case. Calculations for the individual flows are done as described above, but then summed in the case of both the incoming and outgoing visitor flows.

While the above-described process of imputing missing data on tourist food requires several calculations and the combining of data from different sources, it is highly recommended that countries make an effort to include it in their balance sheets. This is because specifically accounting for tourist food as a separate utilization variable is an easy way to remove some error from the estimation of the rest of the balance sheet, as tourist food was previously either not differentiated from food availability, was potentially accounted for in a basket "other utilizations" category, or was simply assumed to be a component of the residual.