Handbook on
Agricultural Cost of Production
Statistics

DRAFT Guidelines for Data Collection,
Compilation

August 2014
Guidelines for Data Collection, Compilation and Dissemination
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Preface

This DRAFT Handbook on Agricultural Cost of Production Statistics (CoP) was prepared under the aegis of the Global Strategy to Improve Agricultural and Rural Statistics (Global Strategy), an initiative endorsed by the United Nations Statistical Commission in 2010. The Global Strategy provides a framework and a blueprint to meet current and emerging data requirements of policy makers and other data users. Its goal is to contribute to greater food security, reduced food price volatility, higher incomes and greater well-being for agricultural and rural populations through evidence-based policies. The Global Action Plan of the Global Strategy is centred on 3 pillars: (1) establishing a minimum set of core data; (2) integrating agriculture in the National Statistical System (NSS); and (3) fostering sustainability of the statistical system through governance and statistical capacity building.

The Action Plan to Implement the Global Strategy includes an important Research programme to address methodological issues for improving the quality of agricultural and rural statistics. The outcome of the Research Programme is scientifically sound and cost-effective methods that will be used as inputs to prepare practical guidelines for use by country statisticians, training institutions, consultants, etc.

So countries and partners can benefit at an early stage from the results of the Research activities already available, a Technical Reports Series was established for wide dissemination of available technical reports and advanced draft handbooks and guidelines. This series will also provide an opportunity to receive early and wide feedback from countries.

Publications in this Technical Report Series were prepared by Senior Consultants, Experts and FAO statisticians, and reviewed by the Scientific Advisory Committee (SAC)¹ of the Global Strategy, the Research Coordinator at the Global Office and other independent Senior Experts. For some research topics, field tests will be organized before final results are included in the handbooks and guidelines under preparation.

¹ The SAC is composed of ten well known senior experts in various fields relevant to the Research Programme of the Global Strategy who are selected for 2 years term. The current membership is composed of Fred Vogel, Sarah Nusser, Ben Kiregyera, Seghir Bouzaffour, Miguel Galmes, Cristiano Ferraz, Ray Chambers, Vijay Bhatia, Jacques Delincé, and Anders Walgreen.
Economic performance indicators for agriculture are a fundamental requirement to improve market efficiency and policy/decision-making. Statistics on agricultural costs of production have historically been among the most useful of such indicators.

This Draft Handbook on CoP presents guidelines and recommendations for designing and implementing a statistical CoP program at country level. It takes into account experiences from countries with existing programs and findings of a recent review of relevant academic and policy literature. It acknowledges that countries differ with respect to both their statistical infrastructure and their objectives, creating country-specific challenges. Nevertheless, this Handbook may serve as a useful reference tool for agricultural statisticians and economists to build or to adapt existing programs for estimating agricultural costs of production, and for analysts to understand the nature and limitations of data from which final indicators are derived.

In addition to outlining a standard methodology, this Handbook will also provide practical and context-specific guidance for countries on cost-efficient ways to produce high-quality and internationally comparable agricultural CoP statistics.

This draft Handbook will be updated with results from in-country field tests and from feedback and experiences of countries. The complete and final Handbook will be published under the Handbook and Guidelines Series.
Acknowledgments

This publication makes direct use of text from a number of sources, in particular the American Agriculture Economics Association’s Task Force Report on Commodity Costs and Returns Estimation Handbook and various methodological reports from National Statistical Agencies on Cost of Production (CoP) programs. References used are provided at the end of the Handbook. It is worth noting that the term, CoP, is not universal, with some countries using instead the terms “cost of cultivation,” “agricultural resource management” or “agricultural costs and returns.”

This Handbook could not have been completed without the cooperation and input from members of the Friends of the Chair Group, formed in 2011 by the Food and Agriculture Organization (FAO) of the United Nations.

The Handbook was also the subject of several workshops and meetings held between 2011 and 2014. The recommendations from these sessions were presented to and approved by the African Commission on Agricultural Statistics (AFCAS), held in Ethiopia in 2011 and Morocco in 2013; the Asia Pacific Commission on Agricultural Statistics (APCAS), held in Vietnam in 2012 and Laos in 2014; the FAO-Interamerican Institute of Cooperation for Agriculture (IICA) Working Group on Agricultural and Livestock Statistics for Latin America and the Caribbean, held in Trinidad and Tobago in 2013; and an expert group meeting of Friends of the Chair, held in Rome in 2013.

The FAO would also like to acknowledge the Global Strategy to improve agricultural and rural statistics for financing this work. The preparation of this publication was supported by the Trust Fund of the Global Strategy, funded by the UK’s Department for International Development (DFID) and the Bill and Melinda Gates Foundation (BMGF).

The written Handbook was prepared by Peter Lys, Senior Consultant, and Franck Cachia, Associate Statistician at FAO’s Statistics Division (ESS), under the guidance of Sangita Dubey and Carola Fabi, Senior Statistician and Statistician, respectively, in ESS.

2 The external experts that participated in the Rome workshop included Jacques Delince (European Union), Peter Lys (Canada), Mohammed Kamili (Morocco), William McBride (USA), Esther Naikal (World Bank), Vikas Rawal (India), Rachele Rossi (EC), David Treguer (World Bank), and Yelto Zimmer (Germany).
The document was edited by Sangita Dubey and laid out by Diana Mohammed Gamal and Arianna Martella.

The Draft Handbook would not have been possible without the generous advice, examples and suggestions from various Friends of the Chair, including Jacques Delince (EU), Mohammed Kamili (Morocco), Peter Lys (Canada), William McBride (USA), Romeo Recide (Philippines), and Yelto Zimmer, along with Vikas Rawal (India) and staff members from the Directorate-General for Agriculture and Rural Development of the European Commission (EC). A thank you also to Josef Schmidhuber, who guided the project at its inception, and the various experts within FAO, too numerous to mention, who contributed their ideas and suggestions.

The most significant contributors, however, remain the many countries who requested such a Handbook, without whom this project would not have begun, and who remain the litmus test as to its value and relevance.
Purpose

The Handbook on Agricultural Cost of Production Statistics, referred henceforth as the Handbook, aims to provide national statistical organizations (NSOs) and Agriculture Departments with a “how to” guide for the collection, compilation, and dissemination of CoP data.

This Handbook is meant to complement work already undertaken in the area of national statistics. Concurrent work underway in other areas of the Global Strategy is not covered in this handbook, but nonetheless, needs to be considered as integral to the overall system of improving agriculture statistics. In particular, items that ought to be considered when applying recommendations within this Handbook and taken from the Action Plan include the following3:

- Guidelines for statistical laws, confidentiality issues, and the establishment of national statistics;
- Guidelines to meet regional specificities;
- Statistical legislation to reflect the integration of agriculture into the national statistical system;
- Guidelines and practices for the development of a master sampling frame;
- Guidelines for sample design based on good practices and research findings;
- Technical standards and guidelines to produce statistics on crop area and yield, livestock and poultry, prices and trade, employment and labor, land use, and fishery and forestry production;
- Technical standards and guidelines for the coordination of agricultural censuses with population censuses; and
- Dissemination standards.

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2

Uses and benefits of Cost of Production statistics

A sound statistical CoP program improves the data and information base for a wide range of issues related to farm operations, including farm accounts’ data on farm cash receipts and farm expenses, net and gross farm incomes, and the degree to which farms are capitalized. It also provides information on farm profitability, household food security and the myriad forms of farm labour, such as hired and self-supplied labour by gender and age group.

As in any data collection program, collecting and processing CoP data comes at a price, which varies considerably depending on the intended uses and users of the data and on the data collection methodology adopted. A classic feature of statistical programs is the asymmetry between costs, which are generally easy to measure and incurred in the short-term, and benefits, which are often intangible, difficult to measure and incurred in the medium to long-term.

This section will strive to identify and quantify the benefits from more complete, accurate and internationally comparable CoP statistics. It will also give an indication of the costs of collecting and compiling this data, and cost variations depending on approaches and methodologies used.

2.1 For Farmers and agricultural markets

While benefits to data suppliers are generally provided only indirectly through improved policy making, better administrative decisions and more efficient markets, CoP statistics can potentially provide direct benefits to the data suppliers also, that is, to farmers themselves.

At the farm level, CoP data can serve as a means to better understand and assess a farm operation. It allows the producer to question his/her own operation and
to benchmark it against the best practices of farms in the same region with similar physical characteristics. This in turn can lead to better farm-level decisions and improved market efficiency and performance.

CoP statistics provides farm extension workers with evidence to support their training and outreach activities, which helps evaluate an individual farm’s management practice against norms for the region. It also allows better targeting to the largest payoffs for their activities, which in turn, elevates productivity.

CoP cumulative distribution curves provide an example of direct use by farmers of such data for benchmarking purposes. Farmers can use these graphs to situate, for example, their holding against all holdings of a similar type. An illustration is provided below for the US (Figure 1) which provides a cumulative distribution of CoP for dairy farms in different regions of the USA. Using this graph, an individual farmer can compare, for instance, the costs of his/her operation to that of the median farm, as well as the farm at the 20th percentile and the 80th percentile in his/her region (around 10 USD/cwt4 for the Fruitful Rim-West region of the US) and other regions.

Figure 1- Regional cumulative distribution of milk operating and ownership costs, 2000

![Cumulative distribution curves](image)


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4 Cwt, also known as a hundredweight, is a unit of measure used in certain commodities trading contracts. In North America it equals 100 pounds (Source: Investopedia).
Farm level CoP data enables farm analysts, be they managers, outreach agents or policy analysts, to assess the effect of farm management decisions on farm efficiency, income and profitability, and advise farmers accordingly. For example, farm analysts can assess the impact of choices regarding the amount and type of variable inputs used, such as fertilizers or pesticides; the type of irrigation method implemented; and the amount and type of capital and technology purchased. This, in turn, enables farmers to understand better how to improve the efficiency and profitability of their operations.

Figure 2 below illustrates differences in profitability for a given commodity, palay, in two different cultivation schemes, irrigated and non-irrigated. This type of analysis is potentially useful for farmers in determining investments in irrigation by enabling them to weigh the costs and benefits of such investments. However, it is possible only with detailed and accurate information on costs and revenues for the different types of operations considered.

![Figure 2 - Net returns for irrigated and non-irrigated palay in the Philippines, 2012](image)

Data source: CountryStat

Finally, more complete and accurate statistics on CoP benefits sectors that provide services to farmers and to the agricultural sector in general, such as banking, insurance and agricultural machine lessors. Improved data on costs and returns facilitate more accurate assessments of financial risks associated with agricultural production, reducing some of the asymmetric information that causes banks and insurers to set high service prices and/or tight supply conditions in sectors, such as agriculture, characterized by high risks and adverse selection. Furthermore, through the ability to assess a potential farm
borrower against the distributional norms in terms of costs of and returns to production, the financial sector is equipped to better design and target financial producers to farmers’ needs at lower prices. The end result of improved access to financial credit by credit-worthy farmers may, in turn, increase efficient investments in agriculture, resulting in higher agricultural output and productivity.

2.2 For policy-makers and governments

CoP information can be and is used by policy-makers to improve the targeting and efficiency of agricultural policies. Better data is necessary in order to appropriately understand the underlying processes that influence the output and productivity of this sector, and how these are impacted by new policies and regulations. For example, accurate CoP data allows a more precise determination of price formation and, therefore, assists both input and output price setting, such as the level and volume of price subsidies to farmers. These derived benefits are compounded by the fact that agriculture is a major direct and indirect contributor to many national economies, especially in the developing world. Because agriculture is so intertwined with households in much of the developing world, this data can help in determining income measures and distributions, and support anti-poverty and food security policies.

In those countries where price supports, investment aid, or import and export decisions are critical, having reliable and accurate CoP data serves to reduce the risk of overpaying or overspending for these programs. Narrowing the range for income and price support typically reduces overpayments to such an extent that the survey program can be funded out of better designed programs. A clear example of this is the mismatch between the prices offered to farmers by the Zambian Food Reserve Agency (FRA) each year, and the actual distribution of costs across farmers, which results in significant over-spending (Box 1)
Box 1 - Costs of ill-designed policies: the example of the maize price scheme in Zambia

In 2009 and 2010, the buying price offered by the FRA for maize was 65000 Zambian Kwacha (ZMK) per 50 Kg bag of maize grain, though 86% of farmers actually produced at a lower cost (the mean CoP 40739 ZMK). This is illustrated by the figure below, which displays the distribution of costs across farms and compares it with the FRA buying price.

The figure also provides an indication of the over-spending generated by the scheme due to the existing buying price. Taking the average production cost of 40739 ZMK (or approximately 9 USD) as the new buying price, the over-spending of the scheme is represented on the figure by the shaded grey area. This area can be approximated by decomposing it into a rectangle and a squared triangle. This will result in a slight over-estimation, given that the curvature of the function is neglected. Using this approach, the coast or over – spending is estimated at approximately 107 million USD for one year of total scheme (see the table below for details). Of course, a different buying price could have been chosen leading different estimates, but this example only intends to provide an illustration of the magnitude of the recurrent and does attempt to present perfectly accurate estimate.

**Estimations of over – spending in Zambia’s maize price scheme, in USD**

<table>
<thead>
<tr>
<th>In USD *</th>
<th>50 Kg bag</th>
<th>Million MT</th>
<th>Quantities (Million MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buying Price FRA</td>
<td>14.3</td>
<td>285714 (A)</td>
<td>2.06 (C)</td>
</tr>
<tr>
<td>New Buying Price</td>
<td>9.0</td>
<td>179073 (B)</td>
<td>1.6 (D)</td>
</tr>
<tr>
<td>B* (C- D)</td>
<td>(A-B)* (C-D)/2</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Over-spending (implicit cost)</td>
<td>$82,373,363</td>
<td>$24,527,604</td>
<td>$106,900,967</td>
</tr>
</tbody>
</table>

* Assumption: 1 USD= 4550 ZMK in 2010

5 Burke et al. (2011). The Cost of Maize Production by Smallholder Farmer in Zambia.
Distribution of maize production costs vs. official buying price in Zambia

FRA price = 65,000 ZMK/bag

Production at cost lower than FRA price = 2.06m MT

40739

1. 6*
2.3 For the System of National Accounts

A properly designed national CoP data program is a required source of information to improve the measurement of intermediate consumption by different agricultural activities and, therefore, their economic value-added. This, in turn, benefits the entire system of national accounts (SNA), through a more accurate description of the economy and a better measure of its total value-added. Furthermore, data on CoP is necessary to construct a proper sequence of economic accounts for agriculture (satellite accounts for agriculture), which in turn provide a detailed description of the formation of value-added in the sector that is unavailable in the broader SNA. Figure 4 illustrates this sequence of accounts.
Finally, the cost estimation of each of the main agricultural activities requires detailed data on input uses and costs, by activity. These technical coefficients can, in turn, be used to construct input-output matrices, which constitute a powerful tool of analysis to better understand the linkages between different agricultural activities and between agricultural activities and the rest of the economy.

Figure 5 provides an example of cost structure for the production of different commodities. On this basis, technical coefficients can be calculated and input-output matrices combined. For example, the purchase of fertilizers for the cultivation of onions will be recorded as an input (intermediate consumption, in national accounting terms) of the agricultural sector and as an output of the chemical industry, which manufactures fertilizers. Products may also appear both as inputs and outputs of the same sector, as in the case of seeds, which are purchased but also produced by farmers.
Figure 5 – Cost structure for different commodities in the Philippines, 2012

Note: Not all available cost items are included.
Outputs, indicators and analytical framework

The best data are meaningless without putting them in context, which often involves defining an analytical framework within which to work. As there is no perfect analytical framework, this Handbook does not suggest a one-size-fits-all approach, providing instead, a list of possible and non-exhaustive outputs and indicators drawing on experiences from countries with well-established CoP programs. It also provides key principles on how to interpret indicators and outputs and how to assess their quality in order to give ensuing analyses and its conclusions credence, confidence and respect.

3.1 Different dimensions of production costs

The type of CoP indicators and outputs that can be produced depends on a series of factors, such as its intended uses and the audience(s) targeted. The data collection vehicle used as well as the underlying quality and level of detail available from farm-level data also shape the analytical framework. For example, data drawn from representative farm surveys may be used to construct regional or national averages, while this may be misleading using data drawn from other sources.

To increase relevance to different actors, different dimensions of production costs and farm profitability should be presented. Farmers, for example, might want to know the return of their operations above cash costs in order to estimate available cash available at the end of the production period. Policy makers and analysts might want total economic costs by activity to understand the relevance of specialization patterns within agriculture and between agricultural activities and the rest of the economy. Economists and analysts might require information on trends in variable and fixed costs. Figure 6 illustrates how production costs can be partitioned into useful components and dimensions to
meet some of these needs.

\[ \text{Total costs} = \text{Variable costs} + \text{Fixed costs} \]

<table>
<thead>
<tr>
<th>Cash Costs</th>
<th>Capital costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchased seed, feed fertilizers, etc.</td>
<td>Depreciation costs and opportunity costs of capital on owned machinery, buildings and farm equipments</td>
</tr>
<tr>
<td>Paid labour</td>
<td></td>
</tr>
<tr>
<td>Custom services (machinery, etc.)</td>
<td></td>
</tr>
<tr>
<td>Farm overhead costs</td>
<td>Unallocated fixed costs</td>
</tr>
<tr>
<td></td>
<td>Farm – level taxes, permits licenses, etc.</td>
</tr>
<tr>
<td>Non Cash Costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Unpaid family labour</td>
<td>Land Costs</td>
</tr>
<tr>
<td>Farm – produced inputs</td>
<td></td>
</tr>
<tr>
<td>Owned animals and machinery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Land rents and imputed rents, land related taxes</td>
</tr>
</tbody>
</table>

Countries can introduce an additional distinction based on the methodology used to compute costs. Some CoP producers distinguish between costs compiled on the basis of data collected at the farm-level and costs estimated using approximations. The latter, called imputed costs, include non-cash costs as well as any cost item for which unit prices are not available, either because the input or capital item is owned by the farm, such as own labour, or because the information reported is unusable.

Combined with information on yields and production, a range of indicators can be defined and compiled to measure the profitability of the farm, in its several dimensions. A preliminary step consists in the choice of the unit (or normalization factor) in which the different measures of costs and profitability will be expressed. This issue is addressed in the following section.

3.2 Normalization Unit

The unit in which the outputs and indicators will be presented first depends on the type of farm activity. The normalization unit should also make sense from an economic point of view, be consistent with the unit used to value output, and be directly understandable and usable by farmers, analysts and other actors.
interested in farm economics. For example, customary units (number of bags of a certain weight or volume, etc.) may be chosen in addition to other measures if this is the unit generally handled on the markets.

**Land area.** This unit is used for cropping activities. Planted area, harvested area or total land area can be chosen, depending on context. If there is an agronomic and economic rationale for leaving part of the land unexploited, such as the case of specific crop rotations, than total area should be used to reflects the production technology of the activity. Land unit should also be defined in relation to the standards managed in the region or country: hectares (ha), acres, etc. Costs can be expressed in a per ha basis, or any other multiple (1000 ha, etc.) if this better reflects regional or national characteristics, such as average farm size. The cost per land area is likely to be more stable in the short term as technology and production techniques vary less year to year than, say, crop yields, which are affected by growing conditions and weather events.

**Output quantities.** These can be used both for cropping and livestock activities. While the normalization by land units better reflects differences with respect to technologies of production, costs expressed on a per output quantity basis provide a more direct measurement of the profitability of the farm. For cropping activities, the unit that is commonly managed in the market can be used: 50 kg bag of maize, 65 Kg bags of cacao beans, etc. Using or converting costs expressed in these customary units in standard units used by data collection agencies at national and international level, such as the Metric ton (MT) or 1000 MT, is also useful. For livestock, costs may be expressed on a per head basis, animal live weight basis or another unit commonly used in the region or country. To better match average herd sizes, costs can be expressed in appropriate multiples, e.g. 100 or 1000 head. The MT can be used to express costs in live weight equivalents or a weight which is closer to the average animal weight, e.g. 250 kg calf. Similar principles can be applied to express costs of livestock products: costs per 1000 liters of fresh milk, costs of producing 100 eggs, etc.

**Output values.** Expressed in this unit, costs provide a direct indication on the profitability and relative competitiveness of the farm operations. This ratio measures the share of costs in gross revenues, i.e. the returns. This indicator has to be consistent with the unit chosen for the output quantities, e.g. if for cattle breeding activities the MT of animal live weight is used, the corresponding value has to be used to express costs: costs per MT of animal live weight valued at farm-gate prices. One of the drawbacks of this measure is that in addition to reflecting production costs, it is sensitive to changes in output quantities and
unit prices, which are affected by a wide range of factors, including external market conditions which are not related to production technologies.

In general, gross indicators will be more stable than residual or difference indicators since they have fewer dimensions. This makes interpreting the results correspondingly simpler, but can also limit the conclusions drawn.

### 3.3 Indicators and output tables

This section will be completed in the final version of the Handbook.

### 3.4 Main economic indicators

Total Costs per ha \([\text{Cash-costs} + \text{Non-cash costs} + \text{Land costs} + \text{Capital costs (replacement and opportunity cost of capital)} + \text{farm overhead expenses}] / \text{Total land area in ha}\). This indicator can be expressed in ha of planted area, MT of output, animal heads for livestock activities or any other unit of relevance, especially customary units. Of course, subsets of the cost indicators can be produced. A common sub-aggregate is to display cash costs or purchased inputs only or to add cash costs and land rental costs. When reliable data is available, indicators can and are often displayed for individual cost items, such as feed costs per animal unit, seed cost per land area, labour cost per MT of output quantity, etc.

**Net Returns per MT of output.** \([\text{Value of output} – \text{Total Costs}] / \text{MT of Output}\). The unit in which total returns are expressed can be chosen amongst the ones presented above, depending on the type of activity, regional or national standards, audience targeted, etc. Subsets of this indicator can be displayed such as returns over cash-costs, returns over cash and non-cash costs, returns over cash and land costs, etc.

**Breakeven price per unit of output.** Total Costs / Total output. The cost variable should reflect total economic costs and the output should reflect only the marketable output, i.e. excluding waste, losses and own consumption. This ratio represents the “breakeven” price or the price to cover the production cost for one unit of product. If unit farm-gate prices are higher than the breakeven price, the farm operation makes an economic profit. Of course several other quotients make sense as well. For example, one could calculate the price required to cover cash costs or total costs excluding opportunity costs.
3.4.1 Additional indicators

A wide range of indicators that relate farm activity to environmental variables can be compiled. These indicators would be useful to characterize the environmental profile of farms within a country or region and to provide some indications on the expected costs for farmers associated with the adoption of environmental policies, such as the shifting to less input intensive practices. Some of these indicators are presented and described below.

**Energy Use per ha** \([\text{Fuel & lubricants use} + \text{electricity use}] / \text{Land area}\). This indicator can also be expressed in terms of production unit. The energy used could be converted to standard energy units (e.g. joules) or could be converted into their monetary equivalents. The individual items summed can be tailored to the uses and include the cost (or volume) of fuel used by machinery, equipment and buildings only, excluding electricity costs. Care should be taken to avoid double-counting, for example if electricity is produced by diesel-powered generators. This indicator, among its many uses, can serve as an input into satellite energy accounts.

**Fertilizer Use per ha** \([\text{Fertilizer use}] / \text{Land area}\). This indicator measures the intensity in fertilizer application for the production of a given commodity. To be relevant for environmental analysis, data on the type of fertilizer used, especially on the concentrations of the different active components, is necessary. Ideally, the application rates per hectare of each of the active components should be provided, but this information may be difficult and costly to collect on a regular basis. Depending on the intended uses of this indicator, organic fertilizers (e.g. manure) may also be included.

**Pesticide Use per ha** \([\text{Pesticide use}] / \text{Land area}\). The comments made for the Fertilizer use indicator also apply for this indicator.

**Environmental Pressure Index** \([\text{Input use} \times \text{Emission Factor}] / \text{Land area}\). This index measures the emissions for a given pollutant associated with the use of a specific input. For example, the quantity of nitrogen application can be translated into nitrous oxide emission using an appropriate emission factor and expressed on a per ha basis. It is worth noting that FAO is already publishing similar indicators, but on the basis of data compiled from different sources (industry organizations, governments, etc.) which do not necessarily reflect the
quantities of inputs used at the farm-level.

In addition to indicators that can be used for environmental purposes, a wide range of statistics measuring returns on the different inputs used can be established. These contribute to measure and identify structural changes taking place in economic sectors, especially in agriculture, where for example higher returns on fixed capital are well-known feature of more sophisticated production technologies.

**Input productivity** \[
\frac{\text{Value of output}}{\text{Input use}}
\]

This indicator measures the gross output in monetary terms generated by a given unit of input (return on inputs). A well-known indicator is labour productivity, which measures the value of output generated by a given unit of labour use (hour, day or month-equivalents, etc.).

**Total Factor Productivity Growth** \[
\frac{\text{Change in the value of output}}{\text{Change in the value of inputs}}
\]

This indicator measures the combined productivity, expressed in constant monetary terms, of all the factors employed in the production of a given commodity, including fixed capital such as machinery and buildings.

**Country examples of indicators and output tables**

**Zambia**

In the example of output table for maize in Zambia (Figure 7), costs are provided at a relatively high level of disaggregation, with a classification adapted to the product under investigation (basal dressing, top dressing, etc.). Cash costs are grouped together and separated from imputed costs for owned inputs (family labour, owned animals and machinery) and from land costs. Three cost aggregates are provided: total cash expenditures, total cash expenditure plus household labour and owned assets (excluding land) and total cost including land cost. The unit chosen is a 50 kg bag of maize. In addition to average costs, expenditures by quintile are provided to display the variability in cost estimates.

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5 For example, the FAOSTAT Domain on Emissions - Agriculture.
Figure 7 – Maize production costs (Zambian ZMK/50 kg bag) by quintile

<table>
<thead>
<tr>
<th>Share of total maize production (%)</th>
<th>Total Cost Quintile (ZMK/50 maize Kg.)</th>
<th>Framer mean</th>
<th>Per 50 Kg. bag mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.4%</td>
<td>27.1%</td>
<td>20.1%</td>
<td>12.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs of production (ZMK/50 Kg.)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hired animal use</td>
<td>283</td>
</tr>
<tr>
<td>Hired machine/tractor use</td>
<td>516</td>
</tr>
<tr>
<td>Hired labor</td>
<td>829</td>
</tr>
<tr>
<td>Basal dressing</td>
<td>1,163</td>
</tr>
<tr>
<td>Top dressing *</td>
<td>1,763</td>
</tr>
<tr>
<td>Fertilizer transport to homestead</td>
<td>39</td>
</tr>
<tr>
<td>Transport cost FRA depot</td>
<td>1,314</td>
</tr>
<tr>
<td>Transport cost to private buyer</td>
<td>2,585</td>
</tr>
<tr>
<td>Herbicides</td>
<td>1,290</td>
</tr>
<tr>
<td>Seeds</td>
<td>1,417</td>
</tr>
<tr>
<td>Total cash expenditures</td>
<td>6,411</td>
</tr>
<tr>
<td>Family Labor</td>
<td>8,274</td>
</tr>
<tr>
<td>Own animal use</td>
<td>873</td>
</tr>
<tr>
<td>Own machine use</td>
<td>1,431</td>
</tr>
<tr>
<td>Expenditures plus household labor and assets (excl.land)</td>
<td></td>
</tr>
<tr>
<td>Expenditures plus household labor and assets (excl.land)</td>
<td>15,567</td>
</tr>
<tr>
<td>Land annual rental</td>
<td>3,364</td>
</tr>
<tr>
<td>Total Cost (incl. land cost)</td>
<td>18,931</td>
</tr>
</tbody>
</table>

Source: Burke et al. (2011)
Philippines

In the example of output table for Palay in the Philippines (Figure 8), costs are partitioned slightly differently: imputed costs are displayed separately from cash and non-cash costs. Imputed costs refer to the costs of owned inputs whereas cash-costs only refer to costs for which no monetary transactions has taken place such as in-kind payments and transfers, etc. Costs are displayed on a per ha basis for the two growing seasons and for the annual average. The cost per Kg of output is only provided for total costs, not for individual cost items. Data is provided on input values and quantities and a series of derived indicators are compiled, among which total costs, returns above cash costs and net returns.
Figure 8 – Costs and returns for Palay (Philippine Pesos) - Extracts

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>January - June</th>
<th>July - November</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Quantity</td>
<td>Value</td>
<td>Quantity</td>
</tr>
<tr>
<td>Production</td>
<td>Kg.</td>
<td>3,499.71</td>
<td>3,280.22</td>
<td>3,408.94</td>
</tr>
<tr>
<td>Area harvested</td>
<td>Ha.</td>
<td>0.98</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>Number of Farms</td>
<td></td>
<td>4,302</td>
<td>3,142</td>
<td>7,444</td>
</tr>
<tr>
<td>CASH COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeds</td>
<td>Kg.</td>
<td>36.80</td>
<td>837</td>
<td>36.60</td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td>Solid</td>
<td>13.24</td>
<td>49</td>
<td>11.69</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>0.57</td>
<td>10</td>
<td>0.36</td>
</tr>
<tr>
<td>Inorganic fertilizer</td>
<td>Solid</td>
<td>202.29</td>
<td>4,686</td>
<td>3,758</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>0.08</td>
<td>21</td>
<td>0.07</td>
</tr>
<tr>
<td>NON – CASH COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeds</td>
<td>Kg.</td>
<td>43.34</td>
<td>675</td>
<td>48.86</td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td>Solid</td>
<td>9.40</td>
<td>18</td>
<td>8.80</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>a'/ c'/</td>
<td>c'/</td>
<td>0.01</td>
</tr>
<tr>
<td>Inorganic fertilizer</td>
<td>Solid</td>
<td>0.59</td>
<td>16</td>
<td>0.67</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Solid</td>
<td>b'/ c'/</td>
<td>b'/</td>
<td>b'/</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>a'/ c'/</td>
<td>a'/</td>
<td>3</td>
</tr>
<tr>
<td>IMPUTED COSTS</td>
<td></td>
<td>8,815</td>
<td>8,743</td>
<td>8,785</td>
</tr>
<tr>
<td>Seeds</td>
<td>Kg.</td>
<td>16.37</td>
<td>363</td>
<td>16.43</td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td>Solid</td>
<td>2.61</td>
<td>14</td>
<td>8.67</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>0.01</td>
<td>2</td>
<td>0.01</td>
</tr>
<tr>
<td>Inorganic fertilizer</td>
<td>Solid</td>
<td>6.55</td>
<td>144</td>
<td>4.26</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>0.01</td>
<td>3</td>
<td>0.01</td>
</tr>
<tr>
<td>TOTAL COSTS</td>
<td></td>
<td>39,307</td>
<td>35,460</td>
<td>37,716</td>
</tr>
<tr>
<td>GROSS RETURNS</td>
<td></td>
<td>53,773</td>
<td>45,434</td>
<td>50,324</td>
</tr>
<tr>
<td>RETURN ABOVE CASH COSTS</td>
<td></td>
<td>37,162</td>
<td>30,588</td>
<td>34,444</td>
</tr>
<tr>
<td>RETURNS ABOVE CASH AND NON – CASH COSTS</td>
<td></td>
<td>23,280</td>
<td>18,717</td>
<td>21,393</td>
</tr>
<tr>
<td>NET RETURNS</td>
<td></td>
<td>14,464</td>
<td>9,974</td>
<td>12,608</td>
</tr>
<tr>
<td>NET PROFIT – COST RATIO</td>
<td></td>
<td>0.37</td>
<td>0.28</td>
<td>0.33</td>
</tr>
<tr>
<td>COST PER KILOGRAM</td>
<td></td>
<td>11.23</td>
<td>10.81</td>
<td>11.06</td>
</tr>
</tbody>
</table>

United States of America

Figure 9 shows costs and returns of corn production in the United States on a per acre basis. The statistics are compiled for the country as a whole as well as for the main corn producing regions (not shown on the figure). The concepts used to group cost items differ from one presented above: operating costs are closer such as family labour: allocated overhead costs include most of the fixed costs such as machinery and equipment but also labour costs, such as management and administrative work. The list of cost items also differs in some respect to the previous output tables: the absence of costs associated with animal use, the presence of taxes and insurance costs, etc. illustrates the differences in the sophistication of production technologies. Complementary information is provided in production practices (irrigated vs. non irrigated), on gross value of production, yields and farm- gate- prices. The information combined with data on CoP is used to compile two indicators measuring the economic profitability of the farm: returns over operating costs and returns over total costs (equivalent Net Returns presented in 3.4).
Figure 9 – Corn production costs and returns per planted acre in the USA, 2011-2012

<table>
<thead>
<tr>
<th>Item</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td><strong>Gross value of production</strong></td>
<td></td>
</tr>
<tr>
<td>Primary Product: Corn grain</td>
<td>836.58</td>
</tr>
<tr>
<td>Secondary Product: Corn silage</td>
<td>1.19</td>
</tr>
<tr>
<td>Total, gross value of production</td>
<td>837.77</td>
</tr>
<tr>
<td><strong>Operating costs:</strong></td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td>84.37</td>
</tr>
<tr>
<td>Fertilizer 2/</td>
<td>147.36</td>
</tr>
<tr>
<td>Chemicals</td>
<td>26.35</td>
</tr>
<tr>
<td>Custom operations 3/</td>
<td>16.77</td>
</tr>
<tr>
<td>Fuel, lube, and electricity</td>
<td>32.42</td>
</tr>
<tr>
<td>Repairs</td>
<td>24.79</td>
</tr>
<tr>
<td>Purchased irrigation water</td>
<td>0.10</td>
</tr>
<tr>
<td>Interest on operating capital</td>
<td>0.17</td>
</tr>
<tr>
<td>Total, operating costs</td>
<td>332.33</td>
</tr>
<tr>
<td><strong>Allocated overhead:</strong></td>
<td></td>
</tr>
<tr>
<td>Hired labor</td>
<td>2.92</td>
</tr>
<tr>
<td>Opportunity cost of unpaid labor</td>
<td>22.77</td>
</tr>
<tr>
<td>Capital recovery of machinery and equipment</td>
<td>89.59</td>
</tr>
<tr>
<td>Opportunity cost of land (rental rate)</td>
<td>138.20</td>
</tr>
<tr>
<td>Taxes and insurance</td>
<td>8.92</td>
</tr>
<tr>
<td>General farm overhead</td>
<td>18.73</td>
</tr>
<tr>
<td>Total, costs listed</td>
<td>281.13</td>
</tr>
<tr>
<td>Value of production less total costs listed</td>
<td>224.31</td>
</tr>
<tr>
<td>Value of production less operating costs</td>
<td>505.44</td>
</tr>
<tr>
<td><strong>Supporting information:</strong></td>
<td></td>
</tr>
<tr>
<td>Yield (bushels per planted acre)</td>
<td>146</td>
</tr>
<tr>
<td>Price (dollars per bushel at harvest)</td>
<td>5.73</td>
</tr>
<tr>
<td>Enterprise size (planted acres) 1/</td>
<td>280</td>
</tr>
<tr>
<td><strong>Production practices:</strong></td>
<td></td>
</tr>
<tr>
<td>Irrigated (percent)</td>
<td>11</td>
</tr>
<tr>
<td>Dryland (percent)</td>
<td>89</td>
</tr>
</tbody>
</table>

This small sample of examples illustrates the diversity in which statistics on CoP are presented. This diversity is the result of multiple factors, some of which are the specificities attached to the commodity under investigation, the level of economic development of the country or region, the sophistication of its agricultural production, as well as social, cultural and religious conditions prevailing in the country.

3.5 Dissemination and interpretation of outputs and indicators

3.5.1 Coping with the variability in Cop statistics

Data and indicators on agricultural costs and returns vary considerably across farms relative to agro-ecological factors (and therefore location), farming practices, farm characteristics such as size, type of commodities produced, type of land tenancy, etc. These wide sources of variation result in the conclusion that there is not a single CoP at national level but a distribution of production costs across the farmers (Burke et. al., 2011).

For these reasons, national and regional averages should be accompanied with more detailed information on the distribution of costs across farmers. For example, costs broken-down by quintiles, deciles, etc, can be displayed as shown in Figure 7. Plotting the full distribution or cumulative distribution of farms is even better (Box 1), as this informs farmers on the profitability of their operations relative to their competitors and helps policy-makers in assessing the effectiveness of price or income support schemes with respect to the actual economics of the activity.

Data and statistics can also be displayed for different farm typologies, which can be constructed on the basis key drivers of farm’s costs and returns. As these groups are more homogeneous with respect to these key drivers, average costs are easier to interpret and to compare across farm types. An interesting example is given in Box 2, which describes how farms groups have been defined in Morocco.
Box 2 – Construction of farm typologies – The example of Morocco

**Introduction**

Presenting data for groups of farms homogenous with respect to factors such as farm specialization and size, which are key in determining economic performance, improves the representativeness of the results and allows for meaningful comparative analysis and evaluations. For example, the economic or environmental impact of innovative farm practices is better assessed for groups of farms which are expected to react in a similar way to changes in their input structure (i.e. which have similar production technologies).

**Process of construction of farm classes**

Cereals are Morocco’s major basic food commodity. Local production covers up to 75% of consumption, depending on rainfall levels. Five classes were determined for the Mekens region farms in the 1991 CoP Survey:
- Class I: farms with land area less than 5 Ha;
- Class II: area between 5-50 Ha and yields less than 55% of the average yield in Wilaya region;
- Class III: area between 5-50 Ha and yields higher than 55% of the average yield in Wilaya region;
- Class IV: area more than 50 Ha;
- Class V: area more than 50 Ha and an irrigated area of more than 20%.

**Uses of farm classes**

Agricultural production planning aimed at characterizing production models requires a method to gather data and compile technical and economic indicators for different types of farms and in different geographical areas. Constructing farm classes is crucial for resource allocation, as subsides and taxes can be more efficiently applied when farm structures and production processes are better understood. Classification is used to present CoP results both in terms of levels (e.g. USD/ton) and structure (e.g. technical coefficients). A proper weighting scheme allows aggregation of CoP values across farm types and regional areas, at both provincial and national levels.
3.5.2 Ensuring and measuring quality in CoP statistics

Statistical quality has several dimensions, of which three of specific interest for CoP programs are briefly described below, along with proposals on how to measure or assess them: relevance, accuracy and precision.

**Relevance.** The extent to which compiled statistics meet the demands of data users, analysts and policy makers. In this context, relevance depends upon both the coverage of the required topics and the use of appropriate concepts. It can be influenced by timeliness, which is a quality assurance dimension not described in this Handbook.

To assess the relevance of collected data and statistics compiled on CoP, the office in charge of data collection needs to have a clear understanding of the main objectives, uses and users of the data and related indicators, which can be multiple and overlapping. Relevance can be assessed using the following types of questions: Will the data be used essentially for policy purposes, such as the setting of price support schemes? Is the data destined in priority to researchers and academics for micro-level analysis? Is the data essential in the compilation of other statistics, such as the National Accounts for Agriculture? The answer to these questions will, to a large extent, condition the design of the CoP program, especially in terms of product or commodity coverage, level of detail and collection frequency. These scoping studies should be conducted at least every five years to ensure the program meets the needs of existing and emerging policy objectives and research topics. In recent years, for example, more and more information is needed on the environmental impacts of agricultural practices and their linkages with the economic performance of the agricultural sector. The extent to which the survey responds to these data requirements will determine its relevance.

**Accuracy** The extent to which compiled statistics measure the desired or true value (bias). It is very unlikely that direct measures of bias can be provided, as sources of bias are multiple and difficult to quantify, and because, by definition, the true value being estimated is typically unknown. However, any type of information likely to give an indication on the possible size and direction of the bias should be provided, including estimates of under or over-coverage of a specific item (commodity, farm-type, etc.) that are likely to lead to an estimation bias, choice of a survey period in which farmers tend to over- or under-estimate their costs, etc. Sources of bias, of course, should be minimized.

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6 UN guidelines on National Quality Assurance Frameworks provide more comprehensive information on quality assurance frameworks developed by national and international organizations, as well as the process to follow to carry-out a proper quality assessment.
to the extent possible, ex-ante, when designing and carrying out the survey (stratification, etc.) and reduced ex-post by appropriate techniques (ex-post stratification, estimation of totals or averages using auxiliary variables, etc.). As an example, the clear tendency for farmers to over-report labour use results in a bias that could be minimized by better framing questions and/or by correcting or scaling raw figures reported by farmers.

**Precision** Measuring precision of the data and its derived indicators, i.e. measuring the uncertainty surrounding the estimation of the true or desired value, is an essential component in quality assessments. Several sources of uncertainty, of a probabilistic or deterministic nature, can affect the estimates of CoP. These sources of errors are associated with the data collection, processing and compilation stage. Section 0 reviews the different sources of errors associated with surveys, the main data collection vehicle for gathering data on CoP, and their impact on the precision of the estimates.

Uncertainty can be measured and treated in many ways. This Handbook recommends, where possible, to compute standard dispersion statistics such as the variance, standard deviation or coefficient of variation of the estimates. For example, the observed variance or standard deviation for any given cost item (total costs, non-specific costs, etc.) can be calculated for homogeneous sub-groups (by farm-type, commodity produced, region, etc.) as well as for the total population of farms, to provide an indication on the overall variability of the estimate in the sample. In addition to the final estimate, upper and lower-bounds based on the observed standard deviation can be provided (e.g. estimate + or – 2 standard deviations). Presenting the full distribution of the estimate among the population of interest is a very powerful tool in assessing the variability of the underlying estimates, as is the presentation of results according to deciles, quintiles or any other relevant population breakdown, including farm size, farm type, and the like.

### 3.6 Summary and recommendations

In this section, different ways of presenting data and indicators on CoP were described and illustrated using country examples. Differences reflect specificities related to the commodity, the country or region and/or the intended uses of the indicators, among a range of other factors.

In addition, advice was provided on how to best cope with the resulting variability in the data and how to provide users with key information on three of the main dimensions of statistical quality: precision, relevance and accuracy.
From this analysis, some guiding principles can be provided on what data and indicators on CoP should be disseminated and how they should be displayed. This Handbook do not suggest that one approach be followed, but provides general recommendations that can be adapted to each specific country context. These recommendations are listed below:

- Variable and fixed costs should be disseminated separately;

- Costs for individual items or sub-group of items should be displayed when reliable data are available;

- The unit of normalisation should be relevant for the commodity analysed and understandable by users (e.g. acres, bags, kg, etc.);

- Data on output quantities and values should be shown, if possible along with key technical parameters such as yields and farm-gate prices;

- Indicators measuring different dimensions of the profitability of the activity should be compiled, such as returns over variable costs, returns over total costs, returns over total costs excluding imputed costs for owned inputs, etc.;

- Data for different regional groupings and/or, size/profitability/cost classes should be compiled and displayed to take into account the distribution in costs across these groupings and classes;

- Where possible, costs should be displayed by quintiles, deciles, or the like, and cost distributions or cumulative distributions among farmers should be plotted;

- Measures of precision should be provided, especially for sampling errors. At the minimum, standard deviations or coefficients of variations should be calculated for the national average and for the sub-groups displayed;

- Potential sources of biases should be identified and, when possible, the direction of the bias and its magnitude should be given.
Considerations on the data collection approach

The uses and purposes of the CoP program should directly determine the nature and characteristics of the data collection phase. This phase must provide the required data with the appropriate properties (coverage, representativity, timeliness, etc.) necessary to compute the indicators and outputs be monitored by farmers, actors of the agricultural and food value chains, policy-makers and analysts. Figure 9 describes this process is described in a simplified scheme.

This section does not propose a single approach to the way data should be collected, but instead, identifies and describes different possibilities with indications on how this impact, at the end of the statistical chain, the characteristics of the data and the quality of the derived indicators. Countries tend to use a combination of data collection approaches for their CoP program, using a mix of survey and administrative data sources (e.g. administered prices and taxes), as shown by the responses of countries to the 2012 FAO questionnaire on country practices. Combining different data sources helps reduce the overall cost of data collection programs and may also contribute to improving data quality and small area detail.

4.1 Data collection vehicles

4.1.1 Survey

Surveys are the most common data collection vehicle used by countries with existing CoP programs (FAO, 2012). The main reason for this is that most of

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the information on CoP is better known by the farmer themselves. In addition, many countries have a long experience in undertaking agricultural surveys in areas such as production and revenue measurement. These information sources and experiences in surveys are leveraged to expand the data collection to areas such as CoP.

It is beyond the scope of this manual to go into all of the details associated with the sample design methodology for CoP survey programs. Comprehensive recommendations for survey design and methodology will be provided by other research projects under the Global Strategy. Nevertheless it is worth pointing out some factors that should be considered by the survey developer when designing a CoP program. This section will provide some background on the survey strategy and on the main sampling designs used in agricultural surveys.

4.1.1.1 Towards an integrated survey strategy

The Statistics Division of the United Nations has been actively preparing guidelines and recommendations for the implementation of economic surveys. Based on best practices observed from NSOs, these guidelines currently exist in draft form8 and are subject to adoption by the UN statistical commission. The essence of the guidelines recommends a holistic approach to survey taking. In particular, the guidelines recommend that countries design economic surveys that can explicitly be used in the preparation of their national accounts. This means economic surveys should be designed, from start to finish, with this purpose in mind. Concepts and standards should conform to the end use, and classification systems used should be consistent with that purpose. The guidelines also suggest the use of a central business register as the sampling frame, and offer several approaches to manage respondent relations.

Noteworthy is the suggestion that agriculture surveys be folded within this integrated survey system approach. The integrated survey approach is, in turn, a key component within the Global Strategy.

The following are key recommendations and highlights of the integration process as it relates to the collection of agriculture data, with explicit recognition of unique country-specific challenges:

- Use the sampling frame(s) as the basis for integration;

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• Create a register of agricultural and rural households using population censuses, and ensure all households, urban and rural/agricultural, are geo-referenced;

• Use remote-sensing products to create an area frame if necessary;

• Establish a register of farms that are above a size threshold and which produce mainly for the markets (so-called commercial farms). These are generally specialty farms or farms so large that it is difficult to establish a linkage with households;

• Use the area frame containing the geo-referenced master household register and the commercial farm register as the basis for all data collections for use in estimating agricultural production;

• Establish a geo-referenced business register. The commercial farm register is a subset, as is enterprises involved in servicing agriculture, such as storage facilities and firms that process meat, poultry, milk, eggs, cotton, wool and other products;

• Establish a core set of data requirements for agriculture and rural statistics and a set of core data classified for the remaining sectors of its statistical system; and

• Once the core statistical system has been defined, define the basic data collections for household and enterprise surveys; and

• Disseminate official statistics in a timely manner, made readily available to all data users, including micro-data (respecting country confidentiality requirements).

4.1.1.2 Stand-alone vs. omnibus surveys

Faced with the objective of collecting data on a wide variety of topics related to agriculture, one of the choices that national statistical organizations have to make is whether they prefer to carry-out single-purpose or multi-purpose
surveys. Single purpose or stand-alone surveys are surveys entirely designed to address one major purpose. Examples abound of stand-alone surveys in agriculture: production surveys, producer price surveys, etc. Conversely, multi-purpose or omnibus surveys are surveys designed to collect data on different (but generally related) topics using a unique data collection vehicle. Examples of omnibus surveys in agriculture are surveys which collect at the same time data on production, revenues and inputs.

As in any data collection program, understanding the issues within the country context helps the program designer make the most informed decision. A survey of country practices revealed many examples of successful programs which use either stand-alone or omnibus surveys to collect farm-level information on CoP. The factors that need to be balanced in selecting the approach includes the survey(s)’s purpose, costs, statistical infrastructure, sector maturity as well as respondent literacy. The decision should also be based on the need of adherence of the country’s overall survey strategy to the integrated approach promoted by the UN guidelines.

**Factors in favor of a stand-alone survey approach:** Like all single purpose statistical surveys, a stand-alone survey designed to estimate the CoP for an agricultural product can be built and designed without the caveats associated with multipurpose or omnibus surveys. In particular:

- Stand-alone surveys can better target the population of interest by allocating all available sample size to that population, thereby reducing sampling complexity and increasing precision and accuracy (or, for a given level of precision, reducing costs). The simplicity also carries forward into data collection, survey processing and estimation activities. Stand-alone surveys can reduce response burden to respondents subject to only one targeted survey, as opposed to an omnibus survey that collects a larger array of variables, and is therefore longer;

- From a data collection point of view, a stand-alone survey can be more easily timed to coincide with farmers practices. If farm record keeping practices are weak or problematic, then it is widely accepted that data collection takes place as near as possible following the event to be recorded. This would necessarily be compromised with an omnibus survey due to the variety of variables of interest. This advantage diminishes as farm record practices in the country improve;

In addition, if cross country comparisons are a desired outcome, then a stand-
alone survey can be designed to facilitate these comparisons in the countries of interest. The objective can be designed into the questionnaire and concepts from the beginning, such as the inclusion of specific variables and questions, rather than fitted and adjusted after the fact.

Finally, for countries without much experience with CoP surveys, a stand-alone survey would allow the focused training and teaching of the data collection staff to conduct a survey consisting of complex concepts. This would also afford the agency with time and experience to understand how best to integrate the CoP program into their ongoing statistical program.

**Factors in favor of omnibus surveys:** The reduction in total costs and data collection load are chief among the advantages of omnibus surveys. Indeed, conducting multiple-purpose surveys significantly leverages data collection resources, in particular:

- As data collection typically represents the most expensive component of the survey process, by combining the number of variables collected, integrated surveys reduce the average cost of collection. This is particularly true if the other data would normally also be collected. Several countries have adopted this approach for these reasons;

- In addition to the collection load, integrated surveys also allow for a reduction in the average costs of data processing given the high share of fixed costs associated with these operations. For example, automatic checks and validation routines are typically developed and tailored to each survey (even if part of the code can be re-used, some adaptation needs to be done). Using several surveys multiplies the time spent on these tasks relative to an omnibus survey.

Omnibus surveys can also facilitate whole farm analysis because, by its nature, it is *de facto* linked to other data collected on the survey. This ranges from other agricultural products, to off farm income and farm family income, to social variables such as owner education.

The total response burden is reduced for those respondents who would otherwise be subject to several stand-alone surveys (even if the survey itself is longer than any of the stand-alone surveys), such as large farms and agribusinesses, and other farms selected into multiple surveys. This occurs as all variables are collected once and only once, as opposed to some variables collected multiple times across stand-alone surveys. Furthermore, these
respondents are contacted fewer times in total. 

One would also normally expect an increase in the quality of the data collected because better consistency checks can be developed through the use of additional questionnaire editing fields (cross-checking information using several variables). For example, if information on income and costs are collected using the same survey vehicle, consistency checks may be implemented to ensure that income declared actually matches farm income.

It is easier to ensure sufficient integration in the survey approach if surveys are designed with multiple purposes because integration is ensured by construction in the design of the survey itself (the same classifications, concepts and variables are used, etc.). Integrating different stand-alone surveys requires a high level of coordination between the different units in charge of the surveys and this process is more prone to errors and omissions.
Box 3 – Omnibus and stand-alone surveys on CoP: country examples

Countries relying on a “stand-alone survey” for the estimation of CoP

In the Philippines, the Costs and Returns Surveys (CRS) have been conducted by the Bureau of Agricultural Statistics (BAS) since 1992. They are mainly aimed at supporting the agricultural Research and Development Program as well as at supporting the formulation of development plans and programs.

In India, since the 1970’s, the “Comprehensive Scheme for Study of Cost of Cultivation of Principal Crops in India”; operated by the DESMOA (Directorate of Economics and Statistics in the Ministry of Agriculture), has provided a common framework for the different Indian States (CSO 2005, DESMOA website ). Cost of cultivation of principal crops (CCPC) surveys directly serve the establishment of Minimum Support Prices (Mehta, 2011).

Countries relying on omnibus surveys for the estimation of CoP

In the United States the CoP data are gathered as part of the annual Agricultural Resource Management Survey (ARMS), in place since 1996. Data in prior years were collected as part of the annual Farm Costs and Returns Survey (FCRS) (USDA-ERS 2012a, 2012b).

In Australia, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has collected CoP data through farm surveys for 33 years (Isermeyer 2012).

CoP estimates in Zambia are drawn from two integrated surveys: the Crop Forecasting Survey (CFS) and the Post-Harvest Survey (PHS) (Burke, Hichaambwa et al. 2011). These surveys are jointly conducted by the Ministry of Agriculture and Cooperatives (MACO-Agriculture Statistics and Early Warning Section) and the Central Statistical Office (CSO) since the 1990’s. CFS is used by the government to calculate the National Food Balance Sheets (NFBS) and as an instrument for information-based policy support in the design of national food security and agricultural development policies (MACO/CSO 2009; MACO/CSO 2011).


4.1.1.3 Sample designs

Sample surveys consist in collecting data for a subset of the targeted population (sample). One of the desirable properties of most of the sample surveys is their ability to provide representative data that can be scaled up to the whole population of farms of a given region or country. Sampling techniques can be categorized in two very broad categories, random and non-random. Each of these can be broken down further into sub-categories. Some of the main survey designs and sampling techniques used for agricultural CoP surveys are described below:

Simple random sampling: Statistical units are selected at random from the population according to an algorithm ensuring that each statistical unit has the
same probability of being selected (equal probability sampling). If the sample rate is set at 10% (i.e., the sample size represents 10% of the population), each unit will have a 10% chance of being selected. Each individual or statistical unit will have the same weight in the sample (in this case each unit in the sample will represent 10 units in the population).

**Probability Proportional to Size sampling (PPSS):** This method, also known as Poisson sampling, takes advantage of the information that exists on the size variable of each of the statistical units (number of ha of land, turnover, revenues, output, etc.). Units are selected with different probabilities according to their size. For example, units twice as large as another will have twice the probability of being selected. This sampling technique is commonly used for agricultural surveys with farm size being the auxiliary variable and results in larger farms having a higher probability of selection than smaller farms. This method can increase the statistical efficiency of the sample if the auxiliary variable (size) is related to the main variables for which information is sought (revenues, costs, etc.). The application of this method requires reliable information on the auxiliary variable for all the units of the population at the sampling stage.

**Stratified random sampling:** The population is first partitioned into several groups (strata) according to one or multiple criteria, such as the main activity of the farm (crops/livestock), the size of the farm, its geographical location, etc. Then, within each stratum, a certain percentage of the population is sampled at random. The probabilities of selection can be equal across strata or can be different. For example, PPSS can be used to select each sub-samples. For a given sample size, stratified sampling can help to reduce the bias and increase the accuracy of the estimates, as it ensures that each stratum is adequately represented in the final sample. Conversely, for a given level of accuracy, stratification allows to reduce the size of the sample. It is important to choose stratification variables related to the dependant variables surveyed in order to maximize the efficiency of the sampling design. Stratification is possible only if the information is available for the stratification variables (farm size, etc.) for all the units of the population.

**Multi-stage cluster sampling:** In cluster sampling, the population is first partitioned into clusters and sub-clusters, for example, representing different geographical locations and scales. For example, a first level of clusters representing squares of 100 km per 100 km can be defined, then a second level composed of 10km per 10km squares and so on. A random sample of clusters is drawn at each level from the sample of higher-level clusters selected in the
previous step. Probabilities of selection of the clusters can be equal or note, depending on the availability and use of additional information to increase the efficiency of the sample (e.g. percentage of total agricultural value-added represented by the cluster). At the end of the process, all the ultimate units within the last randomly selected sample of clusters can be either surveyed exhaustively (a census), or using a previously described method of random sampling. Multistage sampling can considerably reduce survey costs because the target population does not need to be known at all (for censuses in the second stage), or only for the clusters selected (if probability sampling is used in the second stage). However, a larger number of clusters, and hence, larger overall sample might be needed to reduce the risk of ending up with a less representative national sample.

**Non-random sampling:** Samples can also be drawn from partial listings or records which have been gathered in previous studies and for different purposes, provided that information on the dependant variable is available for each of the units. For example surveys can be conducted on farmers that belong to professional organizations and associations to which they provide information regarding their activities. Individuals or statistical units can also be selected on the basis of their supposed importance in relation to the phenomenon surveyed, their ability to provide relevant and reliable information, their interest in the study, etc. In any case, the results drawn from samples that have not been selected on the basis of a random process cannot be extrapolated to the whole population. This constitutes their main limitation. However, the quality of the individual information drawn from these samples can be higher than for random samples, because individuals might be more motivated to provide the information required, they might have a closer relationship with the surveyor, etc. This makes them useful for conducting pilot studies.
Box 4 – Survey design – Lessons from the experience of Indonesia

Introduction

Statistics Indonesia has a long history of providing agricultural CoP statistics. The Indonesian Cost of Production (ICoP) survey was regularly conducted since 1980 to inform governmental policies and decision making. The results of these surveys are disseminated in publications such as the Cost Structure of Paddy and Secondary Food Crops (maize, cassava, sweet potatoes, peanuts, green beans, and soybean) 1980 – 2011. In 2014, Statistics Indonesia will carry out a CoP Survey for some strategic commodities, following the 2013 Indonesian Agricultural Census.

Description of the survey design

Sampling frame

Sampling units of the ICoP are drawn from the Crop Cutting Survey. Three sampling frames were used in the Crop Cutting Survey: 1) a list of census blocks drawn from the agricultural census; 2) a list of households with farmers’ addresses, updated two weeks before conducting the survey; and 3) the list of parcels to be harvested in each sub-round.

There are 3 sub-rounds in a year, January-April, May-August and September-December. On this basis, the ICoP survey used three list frames to select the sample of farmers to be surveyed: a list of districts with harvested areas; a list of the selected census blocks for the Crop Cutting Survey; and a list of households engaged in crop farming with harvested crops in January – August (first 2 sub-rounds).

Sample selection method

The ICoP survey used multistage sampling. First, districts were selected using Poisson sampling, or probabilities proportional to size (value of harvested areas). Next, in each selected district, the census blocks selected were exactly those of the Crop Cutting Survey. Finally, in each census block, enumerators interviewed a sample of households selected from among those engaged in crop farming with crops harvested in January – August.

Sample Size

Depending on the commodities, the sample size varied between 700 households (for green beans) and 5900 households (for wet land paddy).
4.1.1.4 Survey errors

Surveys, of which a census is a specialized case, are subject to two kinds of errors: sampling errors and non-sampling errors.

**Sampling errors.** Sampling error, which only manifests itself with sample surveys, is the degree which the selected sample differs from the population of interest. Sampling error can be estimated for probability based sample designs and is commonly measured as the variance, standard error or coefficient of error of the estimate. These measures reflects the fact that the estimate was indeed based on a random sample and that the true value for the estimate is unknown. It is typically expressed as the probability that the true estimate falls within a specified range with a specified level of confidence. For example, if an estimate is given with a 95% confidence interval, this means that the true estimate will fall within the defined range on average 95 times out of 100. Conversely, this also means that there is a risk of 5% that the true estimate lies outside the confidence interval.

Sampling error can be reduced by increasing sample size, with the extreme case of conducting a census which reduces the sampling error to zero: as a census attempts to collect data from all units of the population, no sampling is required and sampling error disappears. High sampling errors can be the result of ill-designed sampling schemes, estimating for small or unusual populations, the existence of high variability in the characteristics of the population of interest, among other aspects. Sampling errors can be reduced through the application of more sophisticated sampling strategies, such as multistage sampling and the use of auxiliary information, through estimation procedures and as already noted, by increasing sample size. Examples of sampling variances for standard and non-standard sampling designs are given in Box 5

**Non-sampling errors.** Non sampling errors are common to both censuses and to sample surveys. They arise from many different sources and are typically difficult to measure and quantify. If the non-sampling error goes in one direction, then the resulting impact on the estimate will be biased systematically upwards or downwards. Some of the more common sources of non-sampling errors are noted below:

- *Coverage errors:* they occur when the sampling frame or the sample design is missing a portion of the population of interest or alternatively if the sample frame contains unknown duplication. This can lead to a bias in the estimates if the characteristics of the missing sub-population with respect to the variable of interest differ from those of the
population of interest. These errors cannot be reduced by increasing the sample size;

- **Measurement errors**: These errors can be the result of questionnaire design, use of terms which are not understood, recall of the respondent, timing of the survey instrument, interviewer training, misalignment of concepts with questions and language barriers. These errors affect the accuracy of the resulting estimates as the value obtained from respondents does not exactly correspond to the phenomenon that is intended to be measured. This is an important issue for CoP surveys in developing countries as small, medium and sometimes large farmers do not keep record of their expenses. The approach taken for data collection can also affect measurement error: for example, if the survey vehicle is complex and employs a self-administered questionnaire, the chances are that measurement error will be higher than if the data were collected by a highly skilled enumerator;

- **Non response errors**: Non response, either for one question on the survey (partial non-response) or for the entire survey form (total non-response), is a source of non-sampling error. If the non-response is systematic and if the profile and characteristics of the non-respondents are related to the variable of interest (e.g. higher non-response rate among small farmers), then this can lead to biased estimates. If a certain segment of the population does not respond to the survey, then this segment of the population will be under represented in the survey population, potential source of bias.

- Survey non-response can be limited by the adoption of an appropriate data collection approach: a lighter and simple questionnaire will generally reduce the rate of partial and total non-response. Follow-ups with interviewees (by phone or in-person) will also help in reducing non-response and increase the quality of the data. Survey non-response can also be taken into account through estimation methods: for example, missing records can be imputed using matching and other estimation techniques based on the use of data from respondents (hot deck imputation) or external data sources (cold deck imputation).

- **Processing errors**: they arise during the editing and processing stage, after the data have been collected by the statistical authority. Errors can include data capture errors, data coding errors, errors in the computer
programs that process or transform the data. Some of these errors will generally result in outliers (unit mistakes, etc.) which can be detected by the use of data validation and checking rules.

**Box 5 – Determining sampling variance for simple and complex sample designs**

**Introduction**
Consider $Y$, an unobservable variable of interest measurable over the population $U$ of $N$ farms (say, total variable costs) and $S$ a sample of $n$ farms. One of the objectives of surveys is to estimate the unknown quantity $\bar{Y} = \frac{1}{N} \sum_{i \in U} Y_i$ (average variable costs in the population of farms). $\bar{Y}_{est} = \frac{1}{n} \sum_{i \in S} Y_i$ (average variable costs in the sample) is a natural estimate of this quantity. The loss of precision inherent to restriction to $S$ can be measured by the sampling variance or sampling standard error and depends on the way statistical units (farms, households) in the sample are selected from the population (sampling design). In the following, we provide the formulae to compute sampling variances for $\bar{Y}_{est}$ in the case of simple sampling designs. For more complex designs or estimators (ratio estimator, generalized regression estimator, etc.), please refer to *Sampling methods for agricultural surveys*, FAO, Vol. 3, 1989.

**Simple random sampling**
When statistical units are selected at random from a population of size $N$ each unit has the same probability of being included in the sample ($\frac{1}{N}$ for each of the $n$ draws, if the drawings are made with replacement). For this sample design, the unbiased estimate of the variance of $\bar{Y}_{est}$ is given by:

$$s^2(\bar{Y}_{est}) = \left(1 - \frac{n}{N}\right) \frac{s^2(Y)}{n}$$

Where $s^2(Y)$ is the variance of the variable of interest in the sample ($s(Y)$ its standard deviation).

This statistic can also be used to construct confidence bands for $\bar{Y}$. Under the assumption that $\bar{Y}$ follows a normal distribution, its 95% confidence interval is given by:

$$IC_{95\%}(\bar{Y}) = \bar{Y}_{est} \pm 1.96 \cdot s(\bar{Y}_{est})$$

**Stratified sampling**
Consider a partition of the population $U$ in $H$ distinct groups or strata (e.g. classes of farm sizes), each composed of $N_h$ statistical units.

**Case 1**: Within each stratum, each statistical unit is selected using simple random sampling. Each sub-sample, $S_h$, is of size $n_h$, with size $\omega_h = \frac{n_h}{N_h}$, used for weighting. The estimate of $\bar{Y}$ is:

$$\bar{Y}_{est} = \sum_{h \in H} \frac{1}{n_h} \sum_{i \in S_h} Y_i = \sum_{h \in H} \omega_h \bar{Y}_h.$$

The estimated variance of $\bar{Y}_{est}$ is the weighted average of variances within each sub-samples:

$$s^2(\bar{Y}_{est}) = \sum_{h \in H} \left( \frac{N_h}{N} \right)^2 \left( 1 - \frac{n_h}{N_h} \right) \frac{s^2(Y_h)}{n_h}$$

Where $s^2(Y_h)$ is the variance of the variable of interest in each of the $S_h$ (intra-strata variance).
The use of sample surveys to collect data on agricultural CoP is only one of the possible data collection vehicles at the disposal of countries. Several national organisations or regional and global networks have adopted a strategy that consists in devising region specific figures on CoP and other variables on the basis of expert judgment and hard data for a fictive farm. This farm is often referred to as “typical” or “representative”. In this Handbook, we will prefer the first term, to avoid any confusion between the “representative” farm and the statistical representativity of the data, which is not ensured by this approach.

These data collection methods are widely used and should therefore be...
presented and discussed in this Handbook, especially with respect to its complementarities with sample surveys. Brazil’s Companhia Nacional de Abastecimento (Conab), uses this approach to construct regional and national figures on CoP for all the major commodities. The data refers to a fictive farm which, in the case of Brazil, is defined and selected by a panel of experts as the modal farm in the region of interest. Once the modal farm is defined, technical coefficients are determined by the panel for all the variable and fixed inputs. Combined with information on agricultural output and unit prices for inputs, CoP in absolute terms can be determined. Conab’s role is to coordinate the work of the panel, to consolidate the results and to ensure their consistency across time, space (regions) and commodities.\(^9\) The agri benchmark network\(^{10}\), at global level, is another major user of this approach, which is applied to assess CoP for crops and livestock for a wide range of developed and developing countries.

The main steps of the data construction process of the typical farm approach are succinctly described below. Although there may be some variations depending on the countries, commodities and end-uses of the data, these steps are common to most of the countries and organizations using this approach. The subsequent description is appropriate for analyzing international competitiveness of main regions/production systems in a particular commodity. It should be noted that for other purposes it is possible to define other typical farms in - most likely – other regions.\(^{11}\) As far as possible, available statistics are used to (a) identify the relevant region(s) and (b) to identify the relevant farm characteristics such as farm size, production program, combination of enterprises or ownership in land.

**Selection of regions and locations:** For a given commodity, the region(s) to be included in the data construction process are determined on the basis of their importance in the country’s total output. The number of regions selected and the cut-off level depend on the spatial distribution of the production as well as on the end-uses of the data (regional and/or national level information) and on the budget allocated to the program.

**Determination of the typical farm:** One or more typical farms are determined in each of the regions selected for the program. The typical farm can be defined

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\(^{10}\) Agri benchmark is a global, non-profit network of agricultural economists, advisors, producers and specialists in key sectors of agricultural and horticultural value chains. See http://www.agribenchmark.org/agri%20benchmark/who-we-are.html

\(^{11}\) For example if scientists are interested in the economic wellbeing of small holders, typical farms will not be established in the region with the highest share in the total output of a particular crop but in regions, in which small holders are most important.
in many ways but it is generally constructed to represent the most common characteristics of the farms in the region, i.e. the modal farm. Some of the characteristics used in the construction of the typical farm are the:

- Type of production (conventional, organic, etc.);
- Technology used (use of chemical inputs, labour, rate of mechanization, etc.);
- Combination of enterprises (e.g. specialized crop farms, mixed farms)
- Farm size (in ha, output value, etc.);
- Topography and agro-climatic conditions;
- Land tenure type (owned or rented land);
- End-uses of the output (mainly for self-consumption, for selling on national and/or international markets);
- And any other dimension which may reflect local production patterns.

Depending on available statistics, they will be used to redefine those characteristics. In a second step advisors from the selected region are being interviewed in order to define further features of a typical farm. For example, if a majority of farmland in the region is occupied by conventional producers (i.e. non-organic), the typical farm will also be conventional. If a majority of farmers rent their land, the typical farm will also reflect farming practices of rented cropping land, etc.

If different homogeneous groups of farms can be distinguished, each representing a significant share of the production of the region, selecting multiple typical farms to reflect this diversity may help in ensuring a minimal representativity of the derived statistics. This is of course at the price of increased program costs.

**Determination of the panel of experts:** The determination of the modal or typical farm and of its economic characteristics, among which CoP, is done by a panel of experts composed of a wide range of actors of the food and agriculture sector.

The composition of the panels may vary but they generally include:

- Selected number of farmers;
- Cooperatives and associations;
- Extension services and other technical assistance bodies;
- Government and non-governmental organizations related to the agriculture;
Producers of agricultural inputs, machines and equipments; and
Agricultural research organizations.

The main advantage of inviting growers in the panel is that they have their own farm in mind when talking about the typical farm but are not required to disclose any individual information which might be deemed confidential and/or strategic.

The number of participants in a panel is generally limited (3-5 in the agri benchmark network, 10-15 in the case of Brazil) in order to ensure effective discussions and the emergence of a consensus. The organization in charge of the program is generally responsible of the coordination and facilitation of the discussions as well as of the provision to the experts of the required information (data, publications, events, etc.) before, during and after the discussions. It is also responsible for consolidating the results and ensuring their consistency across time, space and commodities.

Data determination process The basic parameters and technical coefficients used to construct data on CoP are determined by the consensus of the group of experts. If available, hard farm-level data should be used as the starting point for the discussions. These parameters are then combined by the organization in charge of the program with data on prices and output levels to construct CoP statistics. The outcome of a cost computing program presented to the panel for cross-checking, which may lead to a revision in the underlying parameters and a new round of calculations. Several iterations might be needed until a consensus on the final results is reached.

The advantages and disadvantages of typical farm approaches, well known, are succinctly described in the following.

**Advantages:** The outcome of this approach is a complete and consistent data set on all major technical and economic parameters of a farm, which allows a reliable estimation of CoP. Since all major technical parameter are documented, it is possible to run all kinds of analysis related to environmental issues (such as GHG emission and nutrient balances). For the same reason it is also possible to analyse all kinds of productivity figures (such as labour, capital and nitrogen). It is also possible to identify options to boost production and/or productivity because, for example, it is known to what degree operations are mechanized and how much labour or inputs are used.

From a global perspective the main advantage of these approaches is that results
are comparable, because data collection and cost allocation is done in a uniform and systematic way. That means results can be used to understand the economic performance of particular production systems in comparison to competitors in other parts of the world.

Of course this level of detail makes the entire process relatively complex and time consuming. Therefore – unless government funding or major sponsoring in individual countries becomes available – the number of typical farms is normally small (+/- 3).

**Disadvantages:** Data constructed on the basis of typical farm approaches do not take into account the full diversity of the production systems and conditions in which farms operate. However, in systems like the Brazilian one a much higher level of special granularity can be realized because greater resources are available, in line with the objective of producing national level reference estimates. However, by construction, the results derived from these approaches cannot be interpreted as national or even regional averages without a significant loss of precision, unless in the specific cases where the production is highly dominated by farms of a single type. This caveat may be addressed, to some extent, by multiplying the number of typical farms. But this leads to an increase of the data collection costs (one of the main advantages of this approach). Moreover, the determination of typical farms is in itself a complicated exercise, given the multiplicity of characteristics to consider and the data requirements on which to base this determination.

**Uses and complementarities with sample surveys:** Given their high level of detail and potential reliability, data obtained from typical farms can be particularly valuable for agriculture outreach officials and policy makers wanting to understand how and to what degree agricultural CoP and farm economics in general depend on the characteristics of the farm, its practices and the environment in which it operates.

Typical farm approaches can also constitute a complement to standard survey-based approaches. For countries with little or no statistical infrastructure, they constitute a cost-efficient way to compile a preliminary set of CoP estimates, which should eventually be improved and completed by sample surveys. They can also constitute an interesting source of information for less important crops for which the use of surveys is not justified economically. Data based on typical farms can also be used as a complementary source of information between two survey rounds.

This Handbook acknowledges the fact that institutions involved in typical farm
Data generation always highlight the fact that one or two typical farms cannot normally be used to create a national average. However, it also acknowledges that they may constitute a relevant source of regional or national-level information in cases where the production of the commodity is highly concentrated in farms of a similar type or when multiple typical farms are selected in order to better reflect the diversity of the farming practices and conditions. It should be noted that – except for the Brazilian case – the agri benchmark approach so far is essentially based on private sponsoring money. In case governments provide additional resources to the establishment and maintenance of typical farms (which would represent a fraction of what is being spent in some countries to analyze current CoP), most of the above mentioned shortcomings could be overcome rather easily.

4.1.3 Other sources of data

Data sources other than survey data can be used as auxiliary information to estimate CoP. These sources are essentially administrative information (tax records, cadastral records, administered prices, etc.) and market data on inputs (market prices of fertilizers, regional wages, interest rates etc.). These sources are generally used in combination with survey data when information is missing (e.g. data missing on values but available on volumes), to impute costs of inputs owned or produced by the farm (e.g. manure, unpaid family labour, etc.), to estimate opportunity costs (e.g. opportunity cost of capital), and to project CoP estimates between two survey years. For example, the USDA uses projections based on production data and fixed technical coefficients to estimate CoP for non-survey years.

An adequate use of these alternative sources of information can also contribute to lower the cost of the data collection process, as explained in 0. Some of the main alternative data sources are shortly described below.

**Administrative sources:** These refer to data and information collected by national or federal governments or by public agencies mandated by the government. Examples include:

- Fiscal and business registries, where a range of information can be found on agricultural holdings;
- Cadastral or land registries, which can provide reliable information on land ownership and characteristics in the region of interest;
• Regulated prices for labour (minimum and/or regulated wages for agricultural activities) and inputs can also be used and combined with survey-based information to compile cost estimates;
• Etc.

Although there is a cost to produce and maintain this data, these are generally well and long-established programs which serve many purposes, often related to tax collection. As a result, the additional costs of collecting and using this information for CoP purposes are very low and this opportunity should be leveraged to the maximum. Data limitations, such as lack of timeliness (e.g. land registries), or issues related to confidentiality, might limit the usability of the data.

**Data from public or private organizations:** Useful data may be gathered from public or private organizations who are involved in agriculture. These include:

• Specialized public and private financial institutions, who can provide information on credits allocated to agriculture;
• Research organizations with experience in analyzing agricultural production;
• Farmers’ union;
• Industry organizations, such as input and machinery suppliers, etc;
• Farm extension services;
• Etc.

The data collected through these sources has to be used and handled with care. It may be partial and/or biased, to suit the interests of the stakeholders of the organizations which collect them. This data may be difficult and/or costly to obtain because of often confidential and strategic nature, which is the case of data from industry organizations, credit information from financial institutions, etc.
4.2 Unit of observation

The choice of the unit of observation is an essential component of the design of the data collection phase. It has a direct bearing on the relevance of the indicators that will be compiled and their comparability with indicators compiled from other data sets. It also directly affects the ability to link these data to other data sets.

The choice of unit is also important from a data accuracy perspective: more reliable data are obtained if questions correspond to interviewee’s ability to report, i.e. if they better match its farm practices and farm record keeping. To the extent that farm record keeping practices are sophisticated, it is important that the survey be designed to coincide with these practices, as evidence suggests that respondents report according to their own record keeping practices.

In the field of agriculture, data can be collected at the level of the farm, the farm enterprise (crop, activity), the plot (generally a subset of the former) and the household.

**Farm (or holding) level** This is probably the level that is the closest to the record keeping practices of the farm and to the interviewee’s ability to report, especially for costs related to inputs that are jointly used by different activities of the farm, and therefore difficult to separate. Data at the farm level is also required to compile key indicators such as farm income and margins, which are necessary to assess the profitability of farming activities as a whole and the economic relevance of the commodity mix adopted by farmers. However, data is also needed at the crop or activity level to measure the relative profitability of different commodities. If this is the case, farm-level estimates will have to be broken-down at the activity level using allocation keys, inevitably leading to less precise activity level estimates.

**Farm enterprise (activity or crop) level:** Crop or activity-level data is necessary to compile crop-level estimates of farm profitability, which in turn are needed to evaluate the relative competitiveness of the different commodities, within the country as well as relative to the same commodities produced abroad. Collecting cost data at this level can be challenging because many cost items, especially but not only fixed costs, are used up jointly by the different activities of the farm. For example, it is difficult, if not impossible, to estimate the energy consumed by the different buildings and electric appliances and equipment attached to the production process of each commodity of the farm. Furthermore, even for inputs which are separable in theory, purchases are
often recorded by the farmer at the level of the economic unit (farm) and not at the activity/crop level. Costs can be allocated using technical factors such as application rates for fertilizers and pesticides, at the risk of reducing accuracy and/or artificially biasing the results.

**Plot level:** Data on costs (and returns) for crops can also be collected at the level of the specific plot of land. At this level, it is easier to relate the data collected on input use to the actual production of a specific plot and, therefore, to ensure that the figure reported make sense from an agronomic and economic point of view (Kg of fertilizers per ha of cultivated land, Labour use per plot, etc.). However, as for crop-level data collection, the question remains of how to allocate non-separable inputs to the specific crops and, in a second step, to the individual plot for which data is gathered. To collect data for individual plots in a statistically sound way, an area frame is ideally needed, from which a sample of individual plots can be drawn. A precise and up-to-date registry of land owners is also useful to connect the plot identified with the appropriate owner and/or manager to which the interview may be addressed. These two conditions are difficult to satisfy, especially in developing countries. However, even without a proper and up-to-date registry of land owners, plots can be selected through area frames and matched to the farm(s) that cultivate it. This is the procedure adopted in many developing countries, especially in Latin America (Ecuador, for example).

**Household level:** The household can also be the unit from which information on costs and returns will be collected, although the survey vehicle used would need to be adapted for that specific purpose. This may be especially relevant in developing countries, where family/household farming is relatively widespread and where farm revenues represent a significant share of the households’ revenues. Collecting data at this level allows compiling indicators that measure food security of households, and relate them with its composition (size, location, etc.) and other variables observable at the level of the household which may be of interest for food security analysis. If this unit of observation is chosen, the list frames, samples and data used and produced within national household surveys could be leveraged to the benefit of the CoP program. This will certainly contribute to limit the budget of the program and improve the quality of the data, by improving its consistency with other variables and facilitating cross-checking and validation (e.g. declared household income and farm revenues, etc.). One drawback of this data collection method is the lack of exhaustivity of the information on costs, as household or family farming constitutes only one of the segments of the universe of farms.
The main considerations in the selection of the unit of observation therefore include:

- The objective(s) of the program, such as the necessity to produce food security indicators for households, to measure the profitability of the production of different commodities and carry-out comparisons with other commodities within the country and abroad;
- The nature of farming in the country, such as the importance of family farming;
- The nature and sophistication of record keeping in the sector. It has to be noted that in most developing countries record keeping is non-existent for most small and medium farms, which represent the great majority of the universe of farms;
- The respondent’s literacy and ability to report the required data;
- The enumerator’s capacity to collect the required data;
- The choice of geographic scale.

**Box 6 – The choice of unit of observation: some country examples**

**Farm holding**
The FADN (EU) collects all CoP data per farm as a whole. As information on commodity specific CoP cannot be taken directly from the data set, it is necessary to estimate them. For example, the FADN collects, at farm level, the monetary value of crop inputs, livestock inputs and other farm costs (e.g. overheads, depreciation, hired labour costs, interest costs). They are not available per unit of commodity (e.g. per ton of wheat, corn or rapeseed, etc.).

**Farm holding and estimation of commodity CoP**
The ARMS (US) collects commodity-specific costs (e.g. direct cost), input quantities and production practices by commodity (e.g. seeds, fertilizers, chemicals). Non-specific costs (e.g. overheads) are collected for the whole farm and are assigned to specific commodities based on an allocation formula.

The same approach is followed in the Philippines, allowing the calculation of average production costs and returns per hectare, per farm and per kilogram (even though the whole farm costs are not released in the Philippines CoP database); and in Sri Lanka where production costs are collected at the estate level but released by quantity of product (per kg or per 1,000 nuts). As estates are mono-specialised, they almost correspond to crop-wise data. This is also the option selected in India according to the so-called “crop complex” approach, meaning that data is collected on all crops grown on all plots farmed, and further allocated to each single crop (Lys 2012). Crop-wise farm level data are then converted into zone level and state level ones.
Commodity or plot
In the 2005 Mauritius CoP survey, operating and fixed costs were collected at the plot level or for a group of plots, in the case of sugarcane planters, since they usually did not keep separate accounts for each plot. Total costs could then be calculated per ha and per kg of product.

Household and plot
The CFS (Zambia) does not include CoP calculation as it is primarily aimed at forecasting the future crop production of the current cropping season. However, they compile enough household and field-level data on input use and production to compute CoP. This was done by Burke et al. (2011) for the direct costs of maize production (cash costs and direct costs of owned factors of production). It is likely that not all overheads costs are covered by the CFS, which may explain why indirect costs were not calculated by Burke et al. (2011).

4.3 Commodity scope

The selection of the products or commodities to include is based on the needs and intended uses of the data. In making this decision, statistical organizations must consider factors such as:

- Relative importance of the product, measured in quantities or value terms;
- Any legislative or statutory requirement attached to specific commodities, such as price support policies, which require up-to-date information on costs and returns;
- The existence of strategic commodities for food security in the country;
- The existence of (or intention to develop) economic accounts for agriculture, which require data on input costs to measure intermediate consumption, value-added and construct input-output matrices;
- The distribution of the commodity across the country (it is easier and less costly to collect data for a commodity which is produced in a well-identified and circumscribed area than for a production more uniformly distributed across the country or area of interest); and
- The budget to be allocated to the program.

Using a consistent classification is the only way to ensure that a statistical agency can obtain estimates for the economy that are complete, unduplicated and internationally comparable. In this respect, it is recommended to use standard industry classifications, such as the ISIC rev.4. Using standard industry definitions and classifications leverages the uses of ensuing data

12 The ISIC detailed structure can be found at http://unstats.un.org/unsd/cr/registry/isic-4.asp.
collections, and allows estimates to be used in the compilation of internationally comparable agriculture sector accounts.

4.4 Geographical scope

The geographical scope to be adopted essentially depends on the intended uses and users of the indicators. If data is intended to be used for the compilation of national accounts for agriculture, it is essential to ensure that the data collected is representative at the level of the country as a whole. CoP data is often required at a sub-national level, given the impact of agro-climatic conditions on farming practices and the need to produce data which can be used to assess regional commodity specialization and relative profitability. An appropriate stratification scheme ensuring regional representativity and allowing an up-scaling of the results at national level is often a pre-requisite to good quality and representative data at different geographical scales.

The geographical coverage of the data collection also depends on the geographical distribution of the commodity: For example, if the production of a given commodity is concentrated in a limited number of regions, it is recommended to focus the data collection efforts on these areas. Data for the residual areas can be either estimated or collected using lighter and less expensive means.

4.5 Frequency and timing

All statistical programs must decide on the frequency of data collection. There is no general prescription for this decision, rather, it is a judgemental question best determined through ongoing dialogue between the statistician and the ultimate data user, within the limits imposed by the financial envelop devoted to the program.

The frequency of CoP surveys depends on several considerations, which include the following:
• Policy use and priority relative to other statistical programs, e.g., such as the need to produce annual estimates to be used in the compilation of annual economic accounts;
• Level of statistical infrastructure and ability to accommodate frequent and infrequent surveys;
• Respondent burden, which imposes a trade-off between frequent surveys and respondent fatigue;
• Factors that impact CoP estimates and the frequency with which these factors change (e.g., adoption of new agricultural technologies; changes in environment/climactic conditions; growth in industrial demand for crops, such as in bio-fuels);
• National or international statistical obligations that require a specific survey frequency; and
• Budget.

If there is a national legislation compelling the collection of annual data, then the question of survey frequency becomes moot. For example, many countries have price and income support programs that dictate how and how often data will be collected. This argument applies equally to any international obligation or commitment made by a country.

The decision of collection frequency, as well as collection timing, must also consider the statistical agency’s capacity to handle the associated workload. Should a survey be conducted during a census year for example? Factors include the number of trained staff, current workload, and technical and physical infrastructure. Not all statistical organizations have the capacity to handle an annual CoP survey, let alone conducting such a survey during a census year.

The policy use of CoP data can also influence the frequency of data collection, with greater frequency likely if the policy use is of high priority and has implications for the treasury. Where statistical infrastructure, in total, is fixed, this requires a trade-off between a CoP program, and other statistical programs.

Collecting data for all commodities every year is necessarily more costly and imposes a significantly greater respondent burden, which in turn could lead to respondent fatigue in the longer term and reduced data quality. Notwithstanding, annual data collection will yield more accurate data and be less dependent on assumptions that are inherent to other approaches. Conversely, collecting data on a rotating basis reduces costs and response
burden, but is dependent on having access to certain data points if one is interested in producing annual estimates. It also makes the implicit assumption that the farm’s production function is stable in the near term. A periodic or less than annual data collection frequencies may affect the time consistency of the data and increase the complexity of the analysis and interpretation of the time series, especially if they are to be used in long-term analysis.

Country experts generally acknowledge that not conducting an annual survey is less than ideal, but also note that in most cases, this is a reasonable trade-off given the benefits of reduced costs, the reduced respondent reporting load and the relative stability in farming practices from one year to the next.

If countries choose a periodicity less than annual, there remains a requirement that base level data (e.g. area harvested, etc.) be collected on an annual basis with which to update the previous CoP survey data. Further, the interval between survey iterations should not be excessive, for example it should not exceed five years. This is not only due to the change of technology or evolution in farming practices, but also the risk that a non-representative year might have been selected for the previous survey or “benchmark”.

Finally, to collect cost data, it is preferable to conduct the survey as soon as possible after the point at which the commodity has been produced and most variable costs have been incurred. This reduces memory bias and increases data quality.

4.6 Costs of data collection

4.6.1 Data collection strategy and costs: an iterative decision process

The costs of collecting the basic data on CoP depends on a series of factors, ranging from the intended uses of the data to the actual data collection and estimation approaches used. As in any statistical program, there is always a trade-off between the completeness and accuracy of the data and the budget that is allocated to the program. The final decision on the amount to be spent on a statistical program, be it a survey or any other data collection mechanism, is ultimately a political decision. The ambition of this Handbook is only to provide decision-makers with all the necessary information and tools in order to help them take a decision which responds to their needs, within the constrained
environment in which they are in, especially with respect to budgetary and technical limitations. It is also the objective of this Handbook to describe the relationships existing between each of the components of a statistical program on CoP and to stress the importance of adopting coherent and integrated strategies from the definition of the needs to the determination of the required outputs and data collection approaches, as illustrated in very simplified and schematic way in Figure 10.

**Figure 10 - Different steps of a data collection program and their linkages**

<table>
<thead>
<tr>
<th>Definition of the NEEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples:</td>
</tr>
<tr>
<td>Improve commodity specialization</td>
</tr>
<tr>
<td>Identify efficient farming practices</td>
</tr>
<tr>
<td>Better targeting of monetary transfers</td>
</tr>
<tr>
<td>Measure pollution abatement costs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Definition of the OUTPUTS and INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples:</td>
</tr>
<tr>
<td>Total variable cost</td>
</tr>
<tr>
<td>Total cash costs</td>
</tr>
<tr>
<td>Net returns per hectare</td>
</tr>
<tr>
<td>Examples of characteristics/properties required:</td>
</tr>
<tr>
<td>Level of precision and accuracy</td>
</tr>
<tr>
<td>Breakdown by activity, by farm type, agro-climatic area</td>
</tr>
<tr>
<td>Annual frequency</td>
</tr>
</tbody>
</table>

| Size of the BUDGET |

<table>
<thead>
<tr>
<th>Determination of the DATA COLLECTION STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples of choices to be made:</td>
</tr>
<tr>
<td>Sample survey vs. other approaches, stratification, size of the sample, periodicity of the data collection</td>
</tr>
<tr>
<td>Unit of observation: farm/activity</td>
</tr>
</tbody>
</table>

| Level of the STATISTICAL INFRASTRUCTURE |
4.6.2 Agricultural censuses and farm surveys

In general, data collection costs increase with the number of individual or statistical units surveyed. Collecting additional information requires transportation costs, additional time allocated to carry-out the data collection, additional processing and validation time, etc. and a range of other costs which vary with the number of interviewees. This is typically true for censuses or sample surveys, where interviewees are located in different areas and for which personal face-to-face interviews are generally carried out. It follows from these principles that censuses and sample surveys require a relatively high budget to be implemented. But these data collection mechanisms are also the ones that can potentially provide the more accurate and meaningful result, either because they are based on a complete enumeration of the population of interest, in the case of censuses, or because they are conceived in order to ensure a certain precision and representativeness of the results, in the case of sample surveys. Given its sensitive nature, information on the costs of carrying out agricultural surveys is seldom available to the public. However, some broad estimates can be provided on the basis of information gathered from different sources. The European Union, for example, contributes to the costs of farm structure surveys carried by member states for a maximum of 160 Euros per farmer interviewed. This contribution only partially covers the data collection costs and does not reflect all the fixed and hidden costs associated with the overall data collection process. It is also worth noting that farm structure surveys in the EU go well beyond what would be requested for a complete CoP survey.

4.6.3 Typical farm approaches

These approaches are based on the use of existing information and on the expert opinion of actors of the sector, including farmers. They do not require the collection of data at the farm-level for a significant number of farmers. As such, they are a considerably lower cost option relative to farm surveys, but do not generally ensure the representativeness of the results, which therefore cannot be extrapolated at the regional or national level.

A hybrid approach, combining the benefits of the typical farm approach with those of full-scale farm surveys, would limit costs while ensuring an acceptable degree of representativity in the results. This approach would consist in undertaking a full-scale structural CoP survey, from which farm typologies would be defined using standard statistical techniques such as principal component analysis and cluster analysis. A very small sample of farms would then be drawn from each of the homogeneous groups and the data from these
farms used as a starting point to define cost structures. Farm typologies would be updated through new full-scale surveys, at a frequency consistent with the pace of technological change in the sector (e.g. every 5 or 10 years).

### 4.6.4 Administrative sources

Although there is a cost to produce and maintain this data, these are generally well and long-established programs which generally serve many purposes, often related to tax collection. As a result, the additional costs of collecting and using this information for CoP purposes are very low and this opportunity should be leveraged to the maximum. Data limitations, such as lack of timeliness (e.g. land registries), or issues related to confidentiality, might limit the usability of the data.

### 4.6.5 Approaches to minimizing the cost of data collection

Many ways exist to limit the cost of collecting data using farm sample surveys as the main data collection vehicle, without undermining the overall quality or usability of the data and results.

**Definition of the population of interest:** A more focused determination of the population of interest in accordance with the needs and objectives of the CoP program will allow one to narrow down the potential universe of farms to be surveyed without reducing the expected accuracy or usability of the resulting indicators and statistics. For example, large farm operations may be excluded from the program if the objective is to assess the profitability of smallholders or if data can be obtained for these units from other more cost-effective approaches. Within the universe of smallholders, only those producing sufficiently in order to generate a marketable surplus could be selected if this is relevant for the purpose of the study. Alternatively, there is no need to include small farm operations if the objective of the CoP program is to assess the profitability of commercial exporting farms compared to competitors in neighboring countries.

**Sampling schemes:** An appropriate sampling strategy allows for a reduction of the number of farms to survey while maintaining a given level of precision in the results (or, conversely, to increase the precision for the same number of units surveyed). In particular, a well-defined stratification scheme based on the variables which are expected to be the most discriminant for CoP (such as activity type, farm size, agro-ecological area, etc.) ensures representativeness with respect to these key dimensions while reducing the required sample size. A
good use of auxiliary variables in the post-stratification or estimation phase can also improve the precision of the results at minimal cost, provided, of course, the auxiliary information is available for the whole universe of the population of interest.

**Data collection mode:** Face-to-face interviews of farmers by enumerators may be necessary when no other interview mode can be used. This is the case when farmers cannot be contacted by mail, phone or email or when illiteracy and insufficient education level does not permit self-filling of questionnaires. In many respects, face-to-face interviews are also a good way to ensure an acceptable response rate and to obtain relatively good quality data. However, it is the most costly interview mode, as enumerators have to be paid for their time and for their transport costs. When the risk on response rates and/or data quality is limited, other data collection modes such as mail, phone or e-mail can be used either in isolation or in combination in order to reduce the overall budget of the program. Large farm operations, for example, which can be expected to have more up-to-date and complete expenditure records could be contacted in priority via mail, e-mail or phone and face-to-face interviews organized only in the case of non-response or poor data quality.

**Frequency of data collection:** The frequency of data collection is dictated to a large extent by the purposes assigned to the CoP program. For example, if minimum prices offered by the government need to be adjusted every year, an annual CoP program seems necessary. Even in this case, however, full surveys of data collection programs do not need to be carried-out. Production functions in agriculture are relatively stable from one year to the next, in normal conditions. It would be acceptable, for example, to undertake a full data collection exercise with a lower frequency, such as every 3 to 4 years, and estimate the costs in between, based on annual production information and on the technical coefficients determined from the survey. If CoP programs are carried-out for more than one commodity, then this means that surveys might be carried out each year on a rotating basis for the commodities including in the program (e.g. wheat in year 1, potatoes in year 2, rice in year 2, wheat in year 4, etc.). This is the approach adopted by the USDA, among others. This allows to distribute the survey costs more evenly across the years.

**Using complementary data sources:** When good quality information is available from other sources than farm surveys, this could be used either as primary information, as a way to improve or derive final estimate, or to cross-check data collected from other sources. The information may come from an administrative or private source. Examples include: using data on regulated
wages to estimate labour costs; using regulated rental prices for agricultural land to impute land rental costs; using data and technical parameters coming from technical studies or farm extension services to proof-check data collected within surveys; etc. The use of complementary information reduces the burden on respondents as questionnaires will tend to focus on the information that the farmer is best able to report. Lighter questionnaires also mean reduced burden for enumerators and faster processing of questionnaires, helping to limit the overall survey costs.
Guidelines for data collection and estimation

This section provides concrete and applicable guidelines for collecting and estimating CoP information. The main categories of inputs considered include: direct expendable inputs, non-specific (or overhead) inputs, labour, capital inputs, land and pre-production costs. Costs can be broken down into many different ways, which do not necessarily overlap: cash (or paid-out) costs and non-cash costs; direct (or specific) costs and indirect (or non-specific) costs; variable and fixed costs; business accounting and economic costs; etc. The breakdown used in this Handbook distinguishes variable costs from fixed costs, as well as those costs which can be directly attributable to a commodity from non-specific ones. Issues related to imputation for owned inputs or the determination of opportunity costs are addressed within each cost item. Given their specificity, pre-production costs and their treatment is addressed separately.

In the following guidelines on the estimation of these cost items, a distinction is generally made between the ideal or “first best” approach and other approaches, which may not be less correct, but are less demanding in terms of data requirements and technical know-how. Finally, fictive or real-world examples are provided to illustrate the methodologies described.

5.1 Basic principles

**Boundaries:** Estimating the CoP for agricultural products involves estimating all economic costs and revenues associated with the production of a commodity. Economic costs differ from standard business or accounting costs because they represent all costs including opportunity costs, not just out of pocket (cash) expenses. This becomes significant for some items, such as owned farm inputs (labour, farm produced feed/seed, etc.) and capital assets,
for which the opportunity cost of capital investments needs to be determined.

All costs should be measured, whether purchased or owner supplied. The basic concept is that if it is necessary for production, the cost must be valued. Cost items that are purchased and spent during the production period include inputs such as seed, fertilizer, and pesticides, as well as hired capital, such as rented machinery or bullock livestock. Costs also include all charges for labour, whether paid for or not, hired or owner provided, paid in kind and/or in cash or sourced from unpaid family members, under daily wages or other contracts.

Marketing expenses and costs incurred to transport products to the market should be excluded from the scope because they relate to distribution and not to the production of the commodity. However, as these expenses directly participate to the selling of the production, it is recommended to keep these costs under scrutiny, especially where access to markets is difficult (for example when government purchases are made outside production areas).

Cost items whose service life extends over several production periods, such as capital service costs (depreciation on owned machinery and buildings), must also be measured. Finally, the opportunity cost of owned capital, including cash used to purchase inputs and the alternative investment return from the use of owner supplied land and animals, must be estimated to fully account for the economic costs associated with producing agricultural goods.

Expenses related to the management of the farm are of a specific nature: they contribute to production in a different way as do the application of fertilizers or the use of harvesting machines, for example. Farm management decisions affect the mix of inputs used and how these are combined together to produce more effectively (which inputs to use, in which quantities, i.e. the production function). Management work, at least the part related to strategic decisions and work, should be reflected in net profit margins. Its inclusion in CoP statistics is therefore a subject of debate in some countries and circles. However, the money spent on hiring farm managers and the time spent by farm owners and the associated opportunity costs can amount to a significant portion of paid out costs, as high as 10% according to Sen and Bhatia (2004). It is therefore necessary to keep track of these expenses and compute estimates of CoP with and without management expenses, as it is done in the case of the Indian Cost of Cultivation program, for example.

It is not the purpose of this Handbook to delve into the details of the data collection on production and revenues. Given their close complementarities with CoP information in measuring farm economic performance, a few general
Measuring revenues consist of adding together returns from the sale of agricultural products, government program receipts, and other miscellaneous revenues. In principle, measuring revenue from the sale of farm products is straightforward, and is equal to the unit price received from the sale of the product multiplied by the quantity sold. Government program receipts are program or support payments that relate to the sale or production of these same products. Special care is necessary regarding the link between government payments to a certain commodity or activity. In case such payments depend on the production / marketing of a certain commodity they should be counted as revenue. However, any direct or decoupled payments should be clearly separated from commodity revenue because in economic terms they rather constitute a lottery gain than reflecting the economic performance of a particular production system. Miscellaneous receipts are those receipts related to the sale of the agriculture product under investigation (sales of cows from a dairy operation for example). Any unsold production that is carried forward in the next production period should be valued as part of accumulated owner-held inventories or stocks.

Valuation: which prices should be used? The prevailing market price is the best price to use to value economic costs and returns. Where there is no market, an imputation that best approximates the market price should be used. In particular, owner supplied inputs should be valued at the market opportunity cost, i.e. the cost of purchasing the same (or similar) input on the market. This includes owner labour and unpaid family labour, as well as other inputs produced and used on the farm, such as manure, which a by-product of livestock production and may be used to provide fertilizer for crop production.

One of the advantages of market prices to value production and inputs is that they reflect the variations in quality of product sold or input purchased. The higher the level of detail in terms of quality attributes attached to products and inputs, the more accurate the estimation of related revenues and costs. Markets for certain products or inputs may be too thin or may simply not exist. In that case, the prevailing market prices for similar commodities or inputs may be used, provided that their use does not lead to excessive bias in the results. For example, land rental agreements for farmers are little used in Morocco (they represented only 10% of the sample in the 1991 CoP survey), limiting the relevance of using average rental rates to impute the costs associated with owned agricultural land. Results including and excluding land costs where therefore presented.
To the extent that markets of a sufficient size exist, local market prices should be privileged over regional or national averages. If markets are too thin, market prices in neighbouring or similar regions may be used.

In general, farm gate prices should be used – both for inputs and for outputs. However, given the high importance of input subsidies – in particular in developing countries – it is of high value to also monitor prices without subsidies. This way it is possible to calculate a proxy for true economic cost as compared to financial CoP. Such a perspective is of relevance in case policy makers have to be informed about the competitive strength and weaknesses of individual production systems and/or commodities compared to the “rest of the world”.

**Timing, inflation adjustment and time discounting:** Differences in the timing of production, cash expenses and selling of products might create inconsistencies between different indicators. This needs to be taken into consideration from a data collection perspective (i.e. questionnaire design and interview process), as well as from an estimation point of view (i.e. inflation adjustment and time discounting). In the case where one common survey is used, questions could focus on total production and expected marketed production as well as on the amount to be used on the farm or taken for own consumption. What is not sold can be valued as a prospective sale or accounted for in inventory using market (or administrative) prices.

It is important that collected revenues and costs refer to the same time period, such as the typical growing year or the calendar year. Both costs and revenues can be adjusted to other time periods if there is an analytical need, provided appropriate adjustments are made to the data to account for the time value of money and inflation.

With the goals of using data for sector and national accounting as well as for facilitating international comparisons, selecting a calendar year is a convenient and, in most cases, a reasonable option. This is due to the fact that most agricultural production can be measured on a calendar year basis, and most statistical systems are designed around disseminating data on a calendar year basis.
Quantities produced should be valued at the farm-gate price at the time the production is actually sold, while inputs should be valued using the corresponding market price at the time the input is used. Revenues and costs should be brought to a common point in time (e.g. last month of the growing year, mid-point of the calendar year, etc.) to ensure that they are comparable (i.e. expressed in common prices) using an inflation rate and, if possible, a time discounting factor (which can be approximated by long-term interest rates).

**Choice of a common unit to express cost and revenues:** It is important that revenues and costs are collected and reported for the same production unit. This means that if data are collected for a given land area, then revenues and costs be collected for the same land area. It is best if this unit is equal to the customary or typical selling unit (e.g. per kg of meat, liters of milk or dozens of eggs). This is because users and suppliers of the data can easily relate to the unit of sale. In the case of crops, using a planted area basis will allow all costs associated with the growing of the crop to be counted even if the area is not in production due to farming practices or is set aside to qualify for government program payments.

**Allocating joint costs to specific activities** In order to fully estimate the CoP for any agricultural product, it is necessary to account for all costs, purchased and owner supplied associated with the production of the commodity in question. For inputs which are solely related to the product in question, this is relatively straightforward.

For inputs that are used in the production of more than one commodity (joint inputs) and in the absence of detailed records that document the quantities of inputs used for a particular commodity, the volume and subsequent value will need to be allocated across the commodities. Typically these are expenses that are purchased for the whole farm and include among other examples, common machinery expenses, farm labour, and expenses associated with multipurpose buildings.

The very nature of this cost category implies that there is no “true” or “false” way to do this allocation. One may argue that there are very rough approaches such as the “per unit approach in case of crops” and more sophisticated ones such as the “machine run time approach” which for example is applied in the agri benchmark Crop branch. The first requirement is therefore to (a) establish a uniform algorithm and (b) to make transparent which one has been used. Ultimately the choice of the allocator used will be dependent on the expense item in need of allocation and the availability of data to the statistician. There are many approaches that are possible and while none are perfect, what is
paramount is that the statistician explains what was done, the underlying assumptions that were used so that the end user can fully understand the data set before him and can make allowances or adjustments to the data set as he sees fit. The most common allocation techniques are described below.

- **Allocation keys**: In determining an allocation formula, the aim is to use reported data as much as possible. For example, if a producer of wheat and maize is able to provide an estimate for total fuel expenses for his tractor, but does not know how much fuel was used for wheat and maize separately, it is not unreasonable to allocate the fuel expense to wheat and maize based on the time that the tractor was used for each commodity or the number of field passes made for each commodity. If this information is not available, the proportion of land cultivated for each crop may be used. Similarly, fertilizer expenses may be recorded as one item for the farm and not be allocated to each commodity. If fertilizer quantities applied to each crop cannot be used to allocate the total cost, a simple allocation rule based on the relative share of land occupied by each commodity may be used.

- These approaches are not exempt of bias and it is important to be aware of the implicit assumptions that are made when choosing among these allocation rules. In this example, the assumption that fuel consumption per ha or that fertilizer application rates are the same for wheat and maize might be flawed. Cases in which the use of these allocation keys are likely to generate a significant bias need to be identified and other methods should be proposed. For example, it is widely agreed that fertilizer intake for wheat and maize vary significantly: if both crops are grown in the same region, the N input to maize would be at least twice as high as for wheat. When looking at maize/soy production systems realized in large parts of the US, Brazil or Argentina this mistake is even more pronounced: soybeans do not receive any N while “neighbouring maize” easily gets treated with 200 kg/ha (app. 200 $/ha).

- Care needs to be taken to ensure that the proportions of tractor use, fertilizer applications and land cultivated sum to 100% and that all of the whole farm expense is allocated to different commodities produced on the farm or to other uses as determined from the survey response.
- **Statistical and econometric techniques:** Formal statistical imputation techniques such as “nearest neighbour imputation” or interpolation might be used provided that a sufficient pool of questionnaires with detailed data on costs by commodity exists. Econometric techniques, based on the assumption that input use is linearly dependant on the quantities produced and that inputs are not substitutable, can be used to estimate ex-post technical coefficients that can be used to allocate costs to specific commodities. This technique, like any other, is prone to errors. The use of advanced statistical techniques, such as maximum entropy estimation, contributes to eliminate the most obvious ones (negative technical coefficients, estimate outside reasonable bounds, etc.). In any case, these approaches should be implemented with care and, before their publication, the results generated should be compared across years and countries to check their reliability.

Beyond the formal techniques that can be used to allocate costs, the way these costs are allocated, grouped and recorded ultimately depends on the nature of the cost:

- For the allocation of machinery expenses, combining information on machinery use (e.g. number of hours of use, land area covered) with engineering data (fuel consumption per hour of use or ha covered, etc.) may lead to more accurate results;
- Allocation keys should be related to the expenses to be allocated. This might involve grouping together expenses according to use. For example, when allocating nonspecific farm machinery expenses, the statistician could group together fuel, lubricants and repair and maintenance expenses. These expenses, when grouped, could in turn be allocated to the product under study according to the machines’ use across all products. In the case of a tractor that is only used for wheat and maize production, the proportion of land cultivated, hours used, or the number of machine field passes for each crop could be used as the allocator for the nonspecific fuel and tractor expenses. Regarding nonspecific livestock expenses, an appropriate allocation key might be the number of heads of each type of livestock raised. However, the statistician shouldn’t use land area to allocate non-specific livestock expenses and animal counts to allocate non-specific crop expenses;
- For overhead expenses that cannot directly be attributed to the production of any commodity, such as some utilities, general business
expenses, and property taxes and insurance, among others, it is generally accepted that these expenses be allocated based on the relative contributions to the whole farm net margins. If net margins are not available, gross margins and in some instances gross commodity receipts can be used to allocate these types of expenses.

Allocation of revenues and costs for joint products: It is common with agriculture activities to produce more than one product. When a specific production technology cannot be identified for each of the activities of the farm, products are said to be joint. A common example is a dairy farm where the primary product is milk but the farm also produces calves and cull cows (meat production). Another example is a cow-calf farm: the main objective is producing a weaner calf but like in dairy there are side products such as cull cows, cull heifers or heifers sold for breeding. Making comparisons on a 'per weaner' basis only would produce distorted results if the proportion of weaner sales in total sales varies significantly between the farms. There are three options to deal with this issue:

- Referring all returns and costs to the main product and producing another chart highlighting the composition of the returns by main product and side product to make the issue transparent. This would be most appropriate in dairy but would overestimate the costs and returns for 'milk production only'.
- Referring all costs and returns to the total weight produced (weaners, cull cows and heifers, breeding cattle). This is most appropriate in cow-calf and products reflected here can be considered more closely related than the milk and the meat in the dairy enterprise.
- Calculating costs of milk production only' or 'costs of weaner production only' by deducting the returns of the side products from the total costs. This suggests an accurate cost picture of the main product but has two issues:

  a) It suggests that for each $ return of each product an equal amount of $ to produce the product is required
  
b) It works for total cost considerations (from which the total returns of by-products can be deducted to obtain one figure of reduced total costs) but not for cost breakdowns. It is neither plausible to deduct the returns from one cost item only nor to deduct the returns on a pro-rata basis from each of the costs items,

13 A weaner calf is a calf no longer fed with its mother’s milk and ready to adopt an adult diet.
especially if these are confronted with returns for profitability analysis.

When different activities within an agricultural holding can clearly be distinguished, each with a specific production function, costs and revenues should be computed at the level of each activity and not at the level of the farm. For example, in a farm combining livestock activity and crops, it is a common practice to use manure, a by-product of the livestock activity, as a fertilizer for the cropping activity. In this situation, manure should be accounted for as a cost for the cropping activity of the farm and as production for the livestock activity, and valued with the appropriate market prices. This ensures consistency and completeness of the farm accounts for each commodity.

5.2 Estimating the cost of variable inputs

Variable inputs are those inputs that vary with the quantities produced and are entirely used during the production year. Inputs such as seeds, fertilizers and plant protection can generally be unambiguously attributable to the commodity production process. This not or less the case for inputs which use is linked to capital equipment, such as energy (fuel, electricity) for machinery, equipment and buildings and water for irrigation.

The methods used to collect the basic data and estimate the costs depend on whether these inputs have been purchased (from farm supply establishments, other farmers, government agencies, etc.) or have been supplied by the farm itself. The most common methods for the estimation of direct input costs are, in order of preference:

- Multiplying the volume of the input effectively used (purchased or owner supplied) by the purchase price inclusive of all tariffs and taxes. If the input was owner supplied, then it should be valued at the price that the product would sell on the market. This is the price that the owner would have to pay if he would opt to purchase this input on the market, i.e. the opportunity cost;
- In cases where volumes or prices of the input are not available, then the production values can be inferred from farm expense records. Care (and if necessary adjustments) must be taken to ensure that the expenses match the production period; and
- In the absence of the first two alternatives, a statistical imputation based on local farm practices can be made by the statistician or enumerator.
This would involve making assumptions (based on common farming practices in the area) on technical coefficients, multiplying by production volumes and by the local market price for the input in question.

The lack of standardisation and differences in quality for mineral fertilisers or plant protection products may increase the difficulty to collect and classify the data and carry-out estimations. The lack of well-functioning markets for these inputs may also impede the use of market prices to impute expenses when inputs are owned by the farm or when data on values or unit prices is missing.

As many of the issues encountered are specific to each input, data collection and estimation methodologies for each of the main variable inputs are given and shortly described below.

**Fertilizers**

**Scope:** Purchase or use of (if owner supplied) of organic or mineral fertilizers. Organic fertilizers are generally owner supplied and include farm, waste, household waste, manure and compost. Mineral fertilizers are chemical compounds such as Nitrogen, Phosphate or Potassium, either pure or mixed using varying compositions. Mineral fertilizers are generally purchased by farmers and are therefore easier to value than organic fertilizers. The latter are often a by-product from other activities and hence are available to the farmer without having to directly pay for them. They only have an economic value (and therefore a price) in case there is a market for these inputs, for example if it is possible to sell them to neighboring farmers. Costs related to the application of these inputs should be excluded and recorded under the appropriate cost items (labour costs, fuel, etc.).

**1st best approach:** Information is collected at the farm-level on the quantities of fertilizers used throughout the growing or calendar year in the typical unit (by kg, bag, etc.), either purchased or owner-supplied. The market prices in practice at the time of the application of the inputs are used to value the quantities in order to obtain an estimate of the costs. Costs are then adjusted to a common reference period using an appropriate inflation rate (and, possibly, time-discounting factor).

**Other approaches:** i) If information is available only on the quantities of fertilizers purchased and not used but if it is common practice in the region or country for farmers not to stock these inputs, then the cost estimate can be
computed by multiplying the quantities by the appropriate market price as explained above; ii) If, in addition, information is only available for the amounts purchased (and not the quantities), then the cost can be estimated by adjusting these values to the chosen reference period; and iii) Finally, if the information collected is too scarce to provide reliable estimates, a standard commodity and region specific application rate (kg per acre for example) can be used to estimate the quantities of fertilizers, pesticides and herbicides used and costs computed by applying the appropriate market price.

**Specific measurement issues:** There is an explicit policy rationale and need to collect information on nutrient quantities. One of the reasons is its importance for sustainability analysis: the nutrient cycle has a major bearing on measuring greenhouse gas emissions from agriculture. Data at this level of detail is also crucial to measure the technical efficiency of agricultural production and identify the conditions under which the productivity of fertilizer application can be maximized. Even with the adequate resources and know-how, the collection of this type of information can be difficult because of the lack of standardization of fertilizer types (a wide range of compositions and mixes can be found) and the insufficient knowledge of farmers on these technical specificities: sometimes, fertilizers are known only by brand names.

**Example:** Information has been collected for one farm on the amount of purchased and owner supplied fertilizers used during the cropping year: 1000 kg of urea and 100 kg of compost produced on the farm. As no information is available on the timing of purchases and application of the fertilizer, we assume that they have been bought during the month preceding the growing season (March to September in this example) and that all the inputs purchased or produced on the farm have been used during the growing season. The market price for urea is 300 USD per metric ton and 50 USD for compost at the time of purchase or production. The reference period is the last month of the calendar year (December) and the inflation rate measured between February (month corresponding to the purchase or production of fertilizer) and December is 2%. The estimated fertilizer cost is calculated in the following way:

\[
\text{Cost} = (1+2\%) \times \left( (1 \times 300) + (0.1 \times 50) \right) = 306 + 5.0 = 311 \text{ USD}
\]

(1+2%) is the factor adjusting prices to the reference period, in this case December.
Plant protection

Scope: Approaches to pest and weed control, achieved by the application of chemicals, such as insecticides or herbicides, through the control and management of natural predators and parasites (biological pest control) or by mechanical means (physical removal of weeds, etc.). Given their predominance, we will focus here on chemical pest and weed control. These include the use of insecticides, fungicides, herbicides and fumigants. As for fertilizers, costs related to the actual application of these chemicals should be excluded and recorded under the appropriate cost items (labor costs, fuel, etc.).

1st Best Approach cf. Fertilizers.

Other Approaches cf. Fertilizers

Specific measurement issues: The valuation of chemicals for pest and weed control is relatively straightforward as these are mostly purchased. As for the fertilizers, most of the chemicals used are known by the farmers by their brand names. There is a wide range of methods to apply these chemicals, such as manual or powered spraying/fumigation, aerial spraying, dusting, mixed application with planting material, etc. The application costs should be allocated to each of the relevant items, i.e. labour and depreciation costs when machines and/or other farm equipments are used.

Planting material

Scope This seeds (nuts), seedlings, cuttings, slips, tubers and spawn. These can be purchased from other farmers or from private sellers, provided by the government or farm supplied (or farm saved). The costs associated with sowing should be accounted for in the appropriate cost item (labour, machinery, etc.).

1st best approach: Costs can be estimated by multiplying quantities and unit prices paid to purchase seeds, adjusted to the reference period. Quantities can be inferred by multiplying standard seed rates by the sowed area. This is also a way to cross-check if the data reported by the farmer on quantities of seed is consistent with the seeding rates observed in the region or locality for the same crop. Usually there is not a market for farm saved seeds. Indeed in many countries it is even forbidden to market farm saved seeds. In these circumstances, the value of commercial grain can be used as opportunity cost for farm saved seed. In practice, as farmers tend to use both commercial and farm saved seeds, it is advisable to collect information on the share of the two
and to calculate an average seed price.

**Other approaches:** Expenses on seeds and other planting material reported by the farmer can also be directly used to estimate costs, after the appropriate adjustment to the reference period. If neither information on quantities nor unit prices/expenses is reported by the farmer, the expenses can be imputed by using standard seed rates and market prices. This again, is subject to the existence of a market for the seeds.

**Specific measurement issues:** Actual seed rates may vary considerably from standard rates: this makes it difficult to validate the information reported on seed. Data on quality and technical characteristics of seeds is needed to inform on technology adoption by farmers, for example the share of high-yielding/hybrid varieties as well as the use of genetically modified varieties.

**Animal feed**

**Scope:** Purchased animal feed products such as feedstuffs blended from various raw commodities (maize, soybeans, oats, etc.) and additives as well as feedstuff produced on the farm (straw, etc.). The costs associated with the actual feeding of animals should be accounted for in the relevant cost items (labour, machinery, etc.).

1st Best Approach cf. above

Other Approaches cf. above

**Specific measurement issues:** Markets for farm-produced feed such as straw may be very thin or inexistent, impeding the use of market prices to impute costs for owner-supplied feed.

**Example:** i) The statistical unit is a farm producing cattle for slaughter. Information is available on the quantity of maize-based meals used on the farm during the calendar year (500 tonnes). Corn waste for silage is used to complete the feeding of the cattle (150 tonnes) produced in the same agricultural holding. The average price of the maize-based meal for the preceding year is 400 USD / tonne. As there is no market for corn silage, the price used is an estimate based on the price of grain: 80 USD / tonne. The annual inflation rate is 2.5%. The estimated feed cost is:

\[
\text{Cost / year} = (1+2.5\%) * \left[ (500*400) + (150*80) \right] = 205000 + 12300 = 217300 \text{ USD}
\]
The size of the cattle is 250 heads. The feed cost per head is therefore:

\[
\text{Cost / year / head} = 869 \text{ USD}
\]

ii) Assume now that monthly market prices are available for the animal meals and that the feeding rates are uniformly distributed over the year \((500/12=41.6\text{ tonne / month})\). Monthly inflation rates are also available. This information is provided in the table below:

**Table 1 –Feed prices in nominal and end-of-period prices**

<table>
<thead>
<tr>
<th>Months</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meals price (USD/ton)</td>
<td>385</td>
<td>410</td>
<td>400</td>
<td>405</td>
<td>408</td>
<td>410</td>
<td>408</td>
<td>415</td>
<td>415</td>
<td>410</td>
<td>410</td>
<td>408</td>
</tr>
<tr>
<td>Current month value ('000 USD)</td>
<td>16.0</td>
<td>17.1</td>
<td>16.7</td>
<td>16.9</td>
<td>17.0</td>
<td>17.1</td>
<td>17.0</td>
<td>17.3</td>
<td>17.3</td>
<td>17.1</td>
<td>17.1</td>
<td>17.0</td>
</tr>
<tr>
<td>Inflation rates, %</td>
<td>0.20</td>
<td>0.25</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.30</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Dec. value ('000 USD)</td>
<td>16.5</td>
<td>17.5</td>
<td>17.0</td>
<td>17.2</td>
<td>17.3</td>
<td>17.4</td>
<td>17.2</td>
<td>17.5</td>
<td>17.4</td>
<td>17.2</td>
<td>17.2</td>
<td>17.0</td>
</tr>
</tbody>
</table>

The total cost is:

\[
\text{Cost / year} = 16500 + 17500 + \ldots + 17000 = 206420 \text{ USD}
\]

And the cost per head:

\[
\text{Cost / year / head} = 826 \text{ USD}
\]

The costs are slightly lower than in the previous computations, as the inflation adjustments are done on a monthly basis: the annual inflation rate is applied to the value of feedstuff used in January, the Feb-Dec rate for the value used in February, etc. In the previous exercise, the annual inflation rate was applied to the full value of the feedstuffs used, implicitly assuming that all the feedstuffs had been used at the beginning of the year.
Other purchased expenses

For reliable CoP estimates, it is essential that all costs are accounted for. In many cases, farm records will combine less important expenses for items together. If these costs can be considered as marginal with respect to other cost items, they may be accounted as one item and, if possible, detail should be provided on the type of costs that are included under that heading. However, if this group of cost items is found to represent a non-negligible share of total costs, an additional breakdown of this group may be needed and costs further allocated to the appropriate items.

5.3 Estimating capital costs

Capital goods (or assets, inputs): Capital goods are treated differently from other inputs because they are not generally used up during the production year. They can be thought of and treated as an input which provides services over multiple time periods. Capital goods\(^\text{14}\) can be structures (buildings) where production takes place or machinery and equipment\(^\text{15}\) used in the production process or animals that are used in the preparation, cultivation and harvesting of the land or commodity. Permanent crops such as orchards as well as livestock used for breeding or to obtain livestock products are also generally considered to be capital because they generate a flow of services over multiple but finite time periods (milk/meat production, wood, fruits, etc.). There are examples of inputs other than machinery inputs that can yield benefits beyond the current production period. This is true for some types of fertilizers. For consistency purposes, but mainly because of the complexity needed to identify the nature and extent of these carry-over effects, it is not recommended to treat these inputs as capital assets. Significant improvements to the land (e.g. terracing) or to its characteristics (e.g. fencing, wells) should also be considered as part of the capital used in farm production.

Capital costs: All the costs associated with the ownership of the capital should be considered and they are essentially of two types: depreciation (the reduction in the useful service life of the capital good) costs and the opportunity cost of capital.

\(^{14}\) This section differentiates capital goods (such as buildings, tractors and other farm machinery) from financial capital that can be placed into investment accounts or instruments.

\(^{15}\) This ranges from large to small farm equipment, including a multitude of tools used by farmers. For practical purposes, farm equipment which costs under a certain threshold can be excluded from the category of capital goods. The European Union system of National Accounts sets this threshold at 500 Euros.
Additional costs associated with the ownership of capital are property taxes, insurance expenses, licenses and fees. These should also be accounted for and grouped in specific items (“Insurance premiums”, “taxes”, etc.).

Consumption of fixed capital (depreciation costs)

Scope: Depreciation costs reflect the reduction in the useful service life or capacity of a capital input (less usable storage space, less number of hours of use for machinery, etc.). This cost, accounted for as consumption of fixed capital (depreciation cost), is normally ascribed to farm machinery, equipment, farm infrastructures (irrigation infrastructure, buildings, etc.). Depreciation costs can also be ascribed to permanent crops, tree plantations or to animals (e.g. dairy cows) that need to be renewed at a certain rate (cacao trees, dairy cows, etc.).

1st best approach: The depreciation of a capital asset reflects the decline in the service life of the asset and its technical obsolescence. Ideally depreciation\textsuperscript{16} of owned capital goods is best measured as the change in the market price of the capital good in question since market values embody these two components. For a given asset, the depreciation cost is equal to the inflation-adjusted change in the market value of the asset between the previous and the current period:

\[
\text{Depreciation Cost (t) = P(t)-P(t-1)}
\]

Where \(P(.)\) is the market price of the asset expressed in the prices of the reference period.

Market prices for certain machinery items such as tractors may be available in public listings, in the same way that there are market prices for used cars. The market prices used should relate to an asset with a given array of characteristics that best matches the farm asset. For example use the market prices for a farm tractor of a certain brand, age, power rating and remaining service life. If a set of market prices are robust and available for similar but not exactly the same asset as the one used on the farm, the depreciation cost can be estimated by applying the percentage change in the market value of the pivot asset to the purchase price of the farm asset as follows:

\textsuperscript{16} It is important to differentiate economic depreciation from accounting or tax depreciation, as specific policy goals often determine the latter, and the two methods provide similar results only by coincidence.
Depreciation Cost (t) = \Delta P (t) \times P (1),

Where \Delta P (t) is the % change in the market value of the pivot asset and P (1) the inflation-adjusted purchase price of the asset.

While simple and desirable as a concept, using the change in market prices for machinery and other capital goods is often difficult because markets with enough transactions to establish representative market prices for these goods are rare.

**Other approaches:** In the absence of reliable market data on the capital good in question, the statistician will have to rely on alternative methods to estimate period to period depreciation estimates. This commonly means making assumptions on the service life of the capital good in question and the rate at which the asset loses its service capacity.

Here there are several depreciation curve schedules that can be considered. A common approach is to use a linear depreciation schedule (also known as “straight line” approach) which consists in depreciating the asset in question in each time period by equal amounts. The difference between the purchase price of the asset and its estimated value at the end of its expected life divided by the number of years of expected service life yields the linear depreciation estimate:

\[
\text{Depreciation Cost (t)} = \frac{P(1) - P(T)}{T}
\]

Where \(P(T)\) is the estimated asset price at the end of its expected service life (its salvage value) and \(T\) the number of years of expected service life. \(P(T)\) is generally a strictly positive number, for example representing the price of the asset when sold to the wrecking yard.

This approach assumes that the loss in service potential is evenly spread out over the expected life of the asset. This isn’t necessarily true and the statistician can choose to use non-linear depreciation schedules if he wishes, for example, to depreciate the capital asset more heavily in the early years. A example of non-linear depreciation schedule for an asset with a service life of 4 years is given by:

\[
\text{Depreciation Cost (t)} = 0.45 \times \left( \frac{1}{t} \right), \text{ with } t=1,2,3 \text{ and } 4
\]
The depreciation schedule given by this formula is: 45% in the first year and respectively 22.5%, 15%, and 11% in the second, third and fourth year. At the end of the fourth year, the asset has therefore been depreciated by a total of 93.5%; in this case, it is assumed that the asset will never be used up entirely.

Another method is the declining balance approach, in which the asset is depreciated at a fixed rate each year, but unlike the linear method, the depreciation rate is applied to the current (depreciated) value of the asset and not the purchase value of the asset. This method suggests that the depreciation schedule (expressed in absolute amounts) is not the same in each year, but has the disadvantage that the asset will never be “used up” entirely. Since this disadvantage becomes negligible when an asset’s service life is large, it is preferable to limit the use of this approach to capital assets with a long service life.

A different family of methods consisting in measuring the portion of the capital that needs to be put aside each year to account for depreciation and opportunity costs can also be used. These techniques, although more complex to implement, but are more accurate from a farm accounting perspective. By design, they treat capital costs as the amount that needs to be provisioned each year by the farmer to ensure that he will be able to purchase a similar asset on the market after the expiration of the service life of its current capital good.

In cases where data on market prices and on the technical characteristics of the capital asset itself cannot or is difficult to collect (useful service life, salvage value, etc.), capital costs can be estimated using the cost of purchasing the capital service from someone else. This approach is based on the assumption that the price of the service provider covers the cost of using his own capital, including both depreciation costs and opportunity costs (see next section). The applicability of this approach depends on the existence of a market for the service and on the availability of observable and representative market rental prices. In many cases, the lending of capital goods (such as machines) by a service providers comes with additional services attached to the use of the capital asset, such as labour and fuel for example (interlocking). In these frequent cases, it is difficult to identify the exact share of capital costs. Using rental rates which incorporate these additional inputs will generally lead to an

\[ A = P_0 - \sum_{t=0}^{T} D_t \]

where \( P_0 \) is the purchase price of the asset and \( D_t \) is its depreciation at time \( t \). In the declining balance approach, \( D_t = \alpha(1 - \alpha)^{t-1}P_0 \). It follows from \( \lim_{t \to +\infty}(1 - \alpha)^{t-1} = \frac{1}{\alpha} \) that \( \lim_{t \to +\infty} A = 0 \).

\[ 17 \] The asset’s value after over its service life, \( T \), is expressed mathematically as: \( A = P_0 - \sum_{t=0}^{T} D_t \) where \( P_0 \) is the purchase price of the asset and \( D_t \) is its depreciation at time \( t \). In the declining balance approach, \( D_t = \alpha(1 - \alpha)^{t-1}P_0 \). It follows from \( \lim_{t \to +\infty}(1 - \alpha)^{t-1} = \frac{1}{\alpha} \) that \( \lim_{t \to +\infty} A = 0 \).
overestimation of capital costs.

**Specific measurement issues:** In some cases, quite frequent in developing countries, assets that are fully depreciated continue to be used. This issue may first arise because of a discrepancy between the effective service life of the asset and the assumed service life used in the calculations. These assumptions are essential to simplify the calculation process, but if these discrepancies are significant and systematic, the parameters should be reviewed accordingly to better reflect the characteristics of the assets used by farmers. More importantly, a difference between theoretic and observed useful service life may also be due to the repairs and maintenance work made on the capital asset (by the farmer or external operators). These items should be accounted for in CoP studies and there are in theory two ways to treat them: if repairs and maintenance activities can be considered as “normal” (e.g. such as change in tires, brakes, etc.), these should be treated as costs. If repairs made lead to increase the useful service life of the asset or improve its service capacity (e.g. change in engine), then these activities should normally be treated as investment, as they contribute to create a new asset with different characteristics.

Another issue, which has been brought many times in this Handbook, relates to the use of market values to estimate depreciation costs. Effective prices tend to vary greatly between different geographical locations. Using market values (new or resale value) in order to calculate depreciation may be possible for the capital city or accessible regions, but may not be relevant for extrapolation to more distant areas where the market is thinner or does not exist. This is especially true for African countries. Hence, even if market values are available, one needs to take care on how to apply them across different locations.

Some capital assets such as farm buildings or vehicles may be used both for the farm itself (i.e. in the production process of the commodity) and for the benefit of the household. In that case, computing the correct amount of depreciation costs becomes more complex. Should the entire value of the asset be entirely attributed to the farm or only a share of it? On which basis should this share be determined? This issue may be of particular relevance in developing countries and for small farmers, which tend to live on the farm. Buildings on the farm may for example be used to store or process commodities but also to store private goods used by the household. Similarly, a farm vehicle may be used for typical farming operations such as the transport of inputs to the farm or
commodities to market, but additionally the farm household for private purposes. In addition, expenses attached to these assets incurred by the household may not be clearly distinguished from overall farm expenses, such as insurance premiums which indistinctively cover farm buildings and the households private living space, fuel expenses for vehicles which are used for private purposes as well as for the farm, etc. In such cases, household-related expenses need to be estimated and subtracted from the total estimate in order to avoid artificially inflating farm expenses.

**Opportunity cost of capital**

**Scope:** Beyond the cost associated with the consumption of the capital asset (depreciation), the opportunity cost of the owner’s investment must also be considered for conceptually correct CoP estimation. The opportunity cost of capital supplied by the owner represents the expected return on capital invested in the farm operation had it been invested in the next best alternative. The actual purchase of capital inputs is not considered to be a cost but rather an investment (acquisition of nonfinancial assets). For example, costs associated with the purchase of trees or cattle for dairy or slaughter should be accounted for as investment costs, not as purchased costs. Loan reimbursements and interest payments associated with the purchase of capital assets are accounted for as a cost (expense) for the farm, but should be grouped in a different cost item, such as “Interest payments on loans”.

**1st best approach:** To estimate the opportunity cost of capital used in the production process, capital assets must first be valued, preferably at current market value. An investment return associated to this amount is then computed by applying an appropriate annual rate of return on capital. As can be readily seen, this can be difficult and subject to error. It involves judgment on the part of the statistician in several dimensions. First the market price of the asset must be determined, often in situations of thin markets for these assets, and second, an assumption must be made on the appropriate rate of return to ascribe to that value.

**Alternative approaches:** In the absence of region and/or area specific rate of returns, long term government bond rates are generally used.
Owning vs. renting capital assets

Instead of owning the capital asset, the farm operator might hire it for a limited period of time. This is a widespread practice in many developing countries, especially in Asia. The development of rental markets has even been recognized as the most important strategy for mechanization of small-holder in sub-Saharan Africa (FAO, 2008). There is indeed an economic rationale to renting high-cost machines and farm equipment which are used periodically and only a few times in the year, such as harvesters, fertilizer spreaders and other types of tractors. Machines can be rented out by other farmers or by specialized service providers. In many cases, in addition to the capital good itself, labour, fuel and other items necessary to the functioning of the machine are also provided. The rental price often consists of a package including all the services related to the performing of a given task and does not generally distinguish between the different types of costs, labour, fuel, capital asset itself, etc. In some cases, these services might be purchased by the farmer for a share of the production instead of a cash payment. In this case, the cost should be based on the revenue foregone had the output been sold in the market, in accordance with the opportunity cost principle.

Two accounting options are available to the statistician, with different implications on data quality and comparability: either the rental costs of these services are grouped under a specific item, for example “Contract or rental services”, or they are allocated to each of the specific cost items, such as labour, fuel and capital costs. The first option is clearly the simplest one but it leads to an underestimation of capital costs for farmers who rent these services. It also risks to affect the comparability of the cost structures between farmers who own capital and those who tend to rent it. The second option is more complex to implement and will inevitably require assumptions which might reduce the relevance and quality of the data. More importantly, given the fact that rental costs generally include implicitly depreciation costs, estimating capital costs for rented capital might lead to double counting. Renting capital and related services is also a measure of the opportunity cost of owning capital for the farmer and this should be reflected in the structure of costs.

From a pure national accounting perspective, the first option should also be recommended as it better reflects the interactions of the agricultural sector with

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19 A farmer’s decision on whether to buy or to rent capital is based not only on the opportunity cost of both options, but on the availability of capital assets on the market and the ability to finance their purchase.
other sectors of the economy (namely, business services, which is a branch of its own in the SNA classification) and the resulting economic flows. Furthermore, at the macroeconomic level, this accounting option better reflects the differences in capital ownership rates between sectors of the economy and avoids double-counting.

Further complicating the issue is that in most cases, the capital good, either owned by the farmer or hired through a contractor, is used in the production of several commodities. The depreciation costs or, if rented, the rental costs of the service provided by the capital asset, should be allocated to a particular commodity. A common allocation key used to allocate machinery related expenses and the associated capital costs is to use the area shares allocated to the different commodities. Other methods are described in 0.

5.4 Labour costs

Labour is an essential input for most of the agricultural activities, both in crop cultivation and livestock rearing. This is especially true in developing countries, which are generally characterized by high labour to capital ratios relative to countries with more sophisticated agricultural production. When adding up the costs associated with the different types of labour employed on the farm, labour costs often represent more than half of total production costs. Although these shares vary significantly according to the commodity produced, labour costs rarely represent less than a third of total costs in developing countries. An illustration of the importance of labour costs for different activities in the Philippines is provided in Figure 11. Labour inputs should therefore constitute an essential component of statistical programs on CoP, from the collection of basic data to estimation and imputation procedures.
The diversity of labour contracts and agreements existing on the farm, especially in large developing countries, constitute a challenge for data collection and cost estimation. Three broad categories can be distinguished: hired (paid) labour, labour for which there is no explicit exchange either in kind, or paid and exchanged labour. Hired labour comprises hired long-term (or full-time) labour and casual (or part-time) labour. Among these categories, differences in the remuneration basis and process create challenges for the data collection strategy and data quality. For example, employees might be paid individually or collectively by a contractor. In the latter case, the determination of the true wage rate used is not straightforward. Unpaid labour comprises a wide range of situations, including owner and family labour (the most common case), community labour (without exchange), labour provided by guests, or other unpaid workers. Finally, farmers can also benefit from exchanged (barter) labour, i.e. labour provided by another farmer or employee of a farm in exchange for a service.
Hired Labour

Scope: Paid labour hired to assist with the production of the commodity. This includes any type of activity, from low-skilled to management work. Labour costs comprise salaries, in monetary terms and/or in-kind payments, as well as all payroll-related taxes and social contributions (social security, pension, health and life insurance) paid by employers. Taxes and contributions paid by employees should be excluded. Any in-kind retribution such as the provision of free or subsidised meals, lodging or share of the production, should be accounted for in labour costs and appropriately valued. In theory, training activities and any type of travel totally or partially covered by the employer and related to the employee’s work on the farm should also be accounted for and valued. In practice, these costs are likely to be negligible in the vast majority of cases, especially in developing countries, and often can be disregarded as far as data collection is concerned.

1st best approach: Labour costs should be computed as the product of the quantity of labour used and the unit wages paid. The quantity of labour is measured by the amount of labour (number of hours/day and total days worked) used for the commodity production process during the production year. Ideally, the time spent by each employee on each of the specific activities of the farm should be recorded and multiplied by the appropriate wage rate, as specified in the labour contract or agreement. This will facilitate the process of apportioning costs across the different enterprises of the farm.

In-kind payments should be valued at the price that these products purchased on the market. If a share of the output is given to the employee, this should be valued using the price that the farmer would have received if he had sold this amount on the market (farm-gate prices) and added to labour costs. If the employee receives a given amount of output at a reduced price, the additional cost to the farmer is the difference between the farm-gate price and the price effectively paid by the employee, multiplied by the amount of produce received by the employee. Similarly, average lodging rental fees in the locality should be used to value on or off-farm lodging provided by the employer, and a standard price of a meal taken outside home to value the food provided free of charge on the farm. It is important to be consistent in the use of valuation methods and include as much as possible all the components of remuneration, of which monetary retribution represents only one part, in some cases not the major one (see labor costs for palay, as shown in Figure 10).
Alternative approaches: In cases where wage rates cannot be easily determined or when the information reported is unusable or simply missing, average wage rates must be used to value labour costs.

Specific measurement issues: When actual wage rates are unavailable there are often multiple alternative wage rates from which to choose, reflecting the diverse tasks (harvesting, sowing, management work, etc.) and sub-sectors in which farms are evolving. For example, wage rates paid to farm workers often do not appropriately reflect the importance and strategic nature of management work. The wage rates used should also, to the extent possible, reflect the economic structures and conditions specific to each sub-sector. An illustration of sector differences in wage rates is given by BAFP (2012)20, for South Africa, where average wage rates ranged from less than R$300 for pineapple production to above R$1200 for sugar cane and citrus fruits. The possibility to use detailed wage rates depends on the existence of markets for each of the types of hired workers in the different sub-sectors.

Additional challenges to the estimation of hired labour costs are created by the difficulty to determine with the appropriate level of accuracy the quantity of labour used. This is the case, for example, for workers who are hired to carry out a given task and who are paid on the basis of the degree of completion of the task, regardless of the time spent working on the farm. These workers are sometimes referred to as piece-rate workers. In this case, while the hiring cost remains easy to collect, information on the time spent by the worker(s) is not necessarily recorded by the farmer.

Allocation of labour costs to each activity or enterprise of the farm also constitutes one of the key measurement challenges. If the farm is involved in different activities (different crops, dairy, cattle, etc.), detailed information on the amount of labour used in the production of each commodity may not be recorded by the farmer. This is especially true for long-term workers who often carry-out different tasks for different enterprises of the farm holding. In order to allocate these costs to each activity, which is needed to construct activity-specific data on labour productivity, allocation keys such as those described for joint costs in section 0 can be used.

Depending on the needs and indicators required, labour costs may also need to be estimated for each of the main tasks carried out on the farm, such as planting, harvesting, and other field activities. This may be difficult as labour,

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20 Bureau for Food and Agricultural Policy (2012), Farm Sectoral Determination: An Analysis of Agricultural Wages in South Africa.
especially regular or long-term workers, may not be hired to carry out a specific task on the farm. In that case, labour costs cannot be directly apportioned to the different tasks but allocation keys can also be used. The allocation procedure will depend on the amount of information available and the farm type and activity. Different cases can be distinguished, as detailed below:

In the first case, labour costs are recorded directly as weekly or monthly expenses of the farm, without distinguishing the amount of labour used for the different activities related to cultivation, to maintenance and repair of buildings and machinery, to administrative tasks, among others. If the farm is involved in the cultivation of different crops (e.g. beans and millet), the allocation of the total labour costs can be made either by using the respective area shares of the different crops or their gross revenue. In the case of mixed-farming, where cropping and livestock activities are combined, it is better to use gross revenue as the allocation key because area shares do not reflect the economic activity of each enterprise. Finally, to split labour costs according to their main sub-items (labour costs associated with harvesting, farm management, etc.), ratios derived from previous surveys or studies which determine the quantity of labor required to perform an activity can be used. The quantity thus obtained can then be valued using an appropriate price.

In the second case, labour costs are distributed across their main sub-items (harvesting, seeding, etc.) but are not apportioned according to the different crop enterprises. In that situation, the allocation rule can be adapted to the type of work undertaken: for all crop-related work, the appropriate allocation key can be the respective area shares of the different crops; for all other expenses, gross revenue shares is generally a more appropriate rule to allocate labour costs.

**Example:** Consider a farm involved in the cultivation of rice and potatoes in a sequential cropping system (growing of the two crops in sequence on the same field during a farming year). The gross annual revenue generated by the cultivation of rice is 9750 USD (70% of the gross revenue of the farm, farm-gate price of 390 USD / ton) while the production of potatoes was 4250 USD (30%, farm-gate price of 85 USD / ton). The activities directly related to cultivation (seeding, land preparation and harvesting) required 63 days of work in the case of rice and 19 for potatoes, at a daily rate of 8 USD. For the remainder of hired labour costs, which represent 20 additional days, neither the commodity to which they are related nor the nature of these costs (repair and maintenance, etc.) are distinguished. Finally, the farm owner distributed for free to its regular employees 50 kg of rice and 25 Kg of potatoes as in-kind
Commodity 1: rice

Hired labour costs directly related to the cultivation (land preparation, seeding, harvesting, etc.) = 63 * 8 = 500 USD

Other hired labour costs = 70 %* (20*8) = 111

In kind compensation (rice) = (50*.39)= 19.5

Total hired labour costs = 111 + 500 + 19.5 = 630.5 USD

Commodity 2: potatoes

Hired labour costs directly related to the cultivation = 19 * 8 = 150 USD

Other hired labour costs = 30 %* (20*8) = 49

In kind compensation (potatoes) = (25*.085) = 2.125

Total hired labour costs = 150 + 49 + 2.125 = 201.1 USD

Unpaid labour

Scope: Unpaid work of the farm owner/operator, of the spouse or any other family member, including working age children, to carry out tasks directly or indirectly linked to the production process. Paid family labour should be treated in the same way as any other type of hired labour (cf. previous paragraph). Unpaid work can also be provided by non-family persons who have ownership rights for the farm, community labour (without exchange), guest workers and other unpaid workers. This section will focus on unpaid family and operator labour, given their predominance in total costs for unpaid labour. The methods used can be applied with few adaptations to other types of unpaid labour, except in very specific situations where opportunity costs are difficult to determine.

1st best approach: Unpaid family labour should be valued using the opportunity cost principle, i.e. by using a salary corresponding to what the family member would get on the labour market in a job corresponding to his “next best alternative”. The nature of the job and salary that a family member
could obtain depends on a multitude of factors: individual characteristics, such as the sex, age, academic qualifications and professional experience of the family member, as well as the existence of employment opportunities in sectors other than agriculture (industry, services, etc.). In some regions, the next best alternative could be a relatively highly paid job in the tourism industry whereas in other areas it might simply be another job in the agricultural sector. This is clearly a complex, time and resource consuming task given the multitude of cases and specific situations.

A relatively efficient method to impute wages for unpaid labour using the opportunity cost principle is to determine, through an econometric estimation, the importance of each of the main factors influencing individual wages. Once these parameters are specified, the observed characteristics of the family member (age, sex, education level, etc.) collected from the farm survey can be included in the equation and the resulting wage used to estimate the cost of labour for this family member. The USDA has considerable experience using this approach using data about the earnings of farm operators in off-farm employment (El-Osta and Ahearn, 1996).

A simple illustration of these so-called hedonic wage equations is provided below:

$$ \hat{\text{wage}}_i = \hat{\alpha} + \hat{\beta}_1 \text{sex}_i + \hat{\beta}_2 \text{educ}_i + \hat{\beta}_3 \text{region}_i + \hat{\beta}_4 \text{age}_i $$

Where:

- $\hat{\text{wage}}_i$ is the estimated wage of individual $i$
- $\hat{\beta}_1$ measures the effect of sex on the wage (e.g. the male vs. female premium)
- $\hat{\beta}_2$ measures the effect of education (e.g. secondary vs. high school diploma)
- $\hat{\beta}_3$ captures the region-specific effect
- $\hat{\beta}_4$ measures the effect of age
- $\hat{\alpha}$, the constant term, can be interpreted as an approximation of minimum salary

Additional parameters can be specified to better capture the determinants of wages. The functional form of the relationship can also be adapted, for example by including a non-linear form to better capture the true underlying dynamics. These parameters can be estimated using household survey data in which
detailed information about hours worked and earnings are available for individuals in the household. This process is relatively data intensive as it requires the collection of additional information on the farmer, its family members (age, level of education, etc.) and on variables defining the economic environment in which the farm operates (region, job market, wages, etc.). Given their structural nature, the type of the variables and the relative importance of each of the parameters remain generally stable from one year to the next. It is therefore not necessary to collect this detailed information and re-estimate the hedonic equations for each survey year. Rather, it is sufficient to carry out these tasks at regular intervals, such as every 3 or 5 years for example or each time farm structural and/or household surveys or censuses are conducted. It should be noted that if macro-economic conditions and characteristics of local job markets change at a faster pace in certain developing countries, more frequent updates to these models will be required.

Alternative approaches: A range of other valuation approaches can be used in replacement of hedonic equations. Average off-farm wages in the region or locality can be used as a proxy of opportunity costs, but this approach does not take into account the differences in skill sets of family workers. Wages used for similar tasks performed on the farm by hired workers can also be applied. Similarly, unpaid owner supplied labour costs can be estimated using average wages for hired farm managers in the same locality or region. Using average or median wages in the agricultural sector, in the locality or region of interest, is likely to be the least costly method but this approach might not reflect the true opportunity costs (unless job opportunities exist mainly in agriculture) and do not account for the variability in wage rates within farms. This is the approach taken by the EU FADN network, among others. Administrative information on official or minimum wages can also be of use to estimate unpaid family work. For example, minimum wages can be used to impute labor costs for young family workers who have few employment options. Similarly, information on wages pertaining to industry organizations, trade-unions or farm extensions services could be used, provided that these data exist and are made available.

Certain approaches may under-estimate the true economic costs if, for example, wages for basic farm activities are used to impute spouse labour when the latter could get a better paid job in another sector, or if average wages for agricultural workers are used to impute owner supplied labour. When possible, the direction and magnitude of potential biases (over or under-estimation) associated with the approach adopted should be clearly identified. Regardless of the method used, once it has been agreed upon it is recommended to apply it in a consistent way across farms and surveys and to make public the associated documentation. As
changes in methodologies may lead to breaks in time-series, it is recommended to avoid changing approaches too frequently, unless it is justified from a methodological point of view.

**Specific measurement issues:** Data on labour use, particularly owner and family labour, is subject to over-reporting by farmers (BFAP (2012) and others). In order to avoid an over-estimation of labour costs, it is recommended to include consistency checks in questionnaires at data collection, input, and validation phases to ensure that the reported amounts are credible and in line with the characteristics of the farm (size, activity, etc.). Given the multiple approaches from which to choose to impute unpaid family work, consistency, transparency and regularity in the application of the chosen method is needed to provide users with good quality estimates comparable across time and sub-sectors.

**Example:** Consider the same farm as in the previous example, involved in the cultivation of potatoes and rice in a sequential cropping system. Recall that hired labour costs amounted to 201 USD for the production of potatoes and 630 USD for rice. Consider now that in addition to hired workers, the farm owner, his spouse and their 16 year-old child take part in the work of the farm. During the year, the farm owner is reported to have worked a full 250 days on activities directly or indirectly related to the production of the two commodities. He spent his time mainly on administrative tasks, accountancy, financial planning, and purchasing of farm materials, equipment and inputs. His spouse provides assistance on administrative tasks as well as additional help during the harvest periods, for a reported total of 50 days per year. Their 16 year old child spent 10 days to help during the harvest periods.

The cost of owner supplied labour is imputed using the average wage for managers in the same region and sector (crops), 20 USD / day, resulting in a total cost of 20 * 250 = 4100 USD for the cropping year. The 50 days worked by the spouse on the farm are valued using the region and sector-specific average wage for supervisors: 13 USD / day, i.e. 13 *50 = 650 USD / year. Finally, the work of their 16 year-old child is valued using the minimum agricultural wage: 6 USD / day, i.e. 60 USD / year.

**Total unpaid labour costs - Farm :**\[4100 + 650 + 60 = 4810 \text{ USD / year}\]

Given the overhead nature of most of the labour undertaken by the owner of the farm and his spouse, gross value-added can be used for the allocation to the different commodities. The costs related to the harvesting work by the child
could be allocated using area shares. As the crops are grown in sequence on the same field, a 50-50 split can be used.

**Total unpaid labour costs - Rice:** \( 70\% \times (4100+650) + 50\% \times 60 = 3355 \text{ USD} \)

**Total unpaid labour costs - Potatoes:** \( 30\% \times (4100+650) + 50\% \times 60 = 1455 \text{ USD} \)

<table>
<thead>
<tr>
<th>In USD</th>
<th>Total Farm</th>
<th>Activity: Rice</th>
<th>Activity: Potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hired Labour</strong> Of which:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeding, harvesting, etc.</td>
<td>630</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>181</td>
<td>130</td>
<td>51</td>
</tr>
<tr>
<td><strong>Unpaid Family Labour</strong></td>
<td>4810</td>
<td>3355</td>
<td>1455</td>
</tr>
<tr>
<td><strong>Total Labour Costs</strong></td>
<td>5641</td>
<td>3985</td>
<td>1656</td>
</tr>
</tbody>
</table>

Note: based on data on wages and yields gathered from various sources.

### 5.5 Custom operations

**Scope** Farmers can choose to provide all of the labour and machinery themselves or might want to hire others to provide like services. Known as custom services, they can range from simple farm tillage or harvesting to virtually any and all of the farm operations. It usually consists of hiring a combination of inputs such as machinery together with fuel, animal for draught, labour and in some cases expendable inputs such as fertilizer or pesticides. In some cases, neighboring farmers might choose to exchange services on each other’s farms. These rental markets are widespread among smallholders, especially in Asia. They are of particular importance for certain commodities, as illustrated in the case of tubers, beans (Mongo) and peanuts in the Philippines (Figure 12). Moreover, the development of these markets has been recognized as the most important strategy for mechanization of smallholder agriculture in Sub-Saharan Africa\(^{21}\). Given their importance for developing

\(^{21}\) See, for example, Mrema et al (2008), Agricultural Mechanisation in Sub-Saharan Africa: Time for a New Look.
countries, a close examination of how these services can be valued and accounted for in CoP estimates is needed.

**Figure 12 – Share of rental services in total cash costs (Philippines, 2012)**


1st best approach: The general principle is that custom services should be valued at the cost to the farmer of the services purchased.

Other approaches: In the case of valuing services traded with a neighbor where no money trades hands, then the statistician should value the input at the cost of purchasing the service from the market or by building up the cost as if it were owner supplied.

Specific measurement issues: The main difficulty concerns the allocation of these costs to each specific items and to each of the activities of the farm. Custom services generally include the provision of a combination of items such as machinery, fuel, labour, fertilizers and pesticides. These expenses should be itemized and recorded separately to the extent possible. This is so that analyst can compare the use of these inputs across other farms which do not use custom services. This is necessary to appropriately estimate total factor productivity or to ensure complete and adequate coverage when constructing satellite accounts such as agriculture, environmental or energy accounts, especially in identifying
appropriately the intermediate consumption flows. If recorded at the level of the farm holding, costs related to custom services need to be allocated to the corresponding commodity or farm activity using one of the methods described in section 0. In cases where expenses associated with the hiring of these services are small relative to other cost items (e.g. less than 5% of cash costs), they can be grouped under a unique item (e.g. Other expenses – custom services).

In the cases in which these services are not purchased but provided for free or as part of an exchange agreement with other farmers, costs have to be imputed. The general practice is to use prices observed in the market for the provision of similar services but, as with other input items, markets might not exist or be too thin to derive accurate estimates.

**Example:** A farmer used the services of a contractor to carry-out fertilizer application on his 2 ha maize field during the cropping year. He recorded the total amount paid, 1000 USD. This amount included all the expenses related to the application of fertilizer (machinery and equipment, fuel, operator, etc.) but excluding the purchase of the substances themselves, which were previously acquired by the farmer.

At the beginning of the cropping year, the farmer bought 250 kg of fertilizer, mainly urea, for a total amount of 100 USD, i.e. 40 USD per 100 kg. The total amount of fertilizer applied by the contractor has also been recorded: 200 kg, i.e. 100 kg per ha. Therefore, the total cost of fertilizer (excluding application) amounted for that cropping year to 80 USD, i.e. 40 USD / ha. This amount has to be recorded as fertilizer costs, as it would have been if the application had been done by the farm operator himself.

The fertilizer application has been carried out over two days by one operator. No detailed information is available on the effective hours spent by the operator. It can be assumed that the operator worked for two full days, i.e. 16 hours in total if a standard working day of 8 hours is assumed. The total labour cost related to this operation is obtained by multiplying the number of hours worked by an appropriate hourly wage. Ideally the hourly rate should be the same than the one a similar farm employee would get in the farm. If this is not available, average wages for similar tasks in the locality, region or country can be used. Here, a rate of 10 USD per hour is assumed. The total labour cost related to fertilizer application for this farm is therefore 160 USD, i.e. 80 USD / ha. This amount has to be recorded as labour costs, as it would have been if the application had been carried out by the farm operator or one of his employees.
Fuel expenses can be determined using an estimate of the average fuel consumption per hour of use or surface covered for similar machines. These technical factors or engineering equation are usually available in specialized reviews. The AAEA Handbook provides details on this (section 5-32). For example, assuming that a tractor with a maximum horsepower per hour of 100 was used for the fertilizer application, for a total of 4 hours, the total diesel consumption amounts to approximately 175 gallons. Using an average price per gallon of 3.5 USD, estimated fuel costs amount to 613 USD, i.e. 306 USD/ha.

Total or part of the residual cost (1000-613-160=227) can be recorded as capital depreciation, as it can be assumed that if private contractors act rationally these costs should be included in their fees. Residual costs can also be allocated partly to repair costs, as they should also be accounted for in the fee. If this allocation is not possible given data, time or resource constraints, or if these hired services do not represent a significant share of total costs, this amount can be included in a specific item grouping other custom costs, such as Other expenses – custom costs.

Summary:

Fertilizer costs (excluding application) = 80 USD (40 USD / ha) => Fertilizer costs

Custom costs – Labour = 160 USD (80 USD / ha) => Labour costs

Custom costs – Fuel = 612 USD (306 USD / ha) => Machinery and equipment

Custom costs – Other = 227 USD (113.5 USD / ha) => Other costs

Veterinary expenses

Veterinary expenses are a different type of custom service in the sense that farmers or farm employees cannot generally perform these tasks by their own, contrary to, for example, fertilizer application seeding or harvesting. Given their specificity, these costs have to be recorded separately. These costs include medications and supplements administered to animals that are not mixed with feed. Some examples include administered vitamins, hormones, medications used to counter external and internal parasites. Veterinary fees and costs associated with products (needles, gloves etc) used to administer these products should also be included. These costs are generally attributable to one
commodity, unless different types of animals are raised on the farm. They should be estimated by multiplying quantities (e.g. number of visits) by unit prices or, by default, by using the values provided in farm records. The latter might be more relevant if farmers purchase a given package of veterinary services and do not pay on a per visit basis.

5.6 Land costs

Scope: Land used for agricultural production is a unique input: unlike variable inputs which are typically used within one production cycle or capital inputs which generally have a finite service life, the services provided by land, when properly cared for, can last indefinitely. Land can be owned or rented under a wide range of contractual or tacit arrangements, which render its proper evaluation for CoP often complex and contentious. Infrastructures on the land (housing, sheds and other farm buildings) which, depending on the context, should be either excluded or valued separately, add to the complexity. The expenses associated with owner occupied farm housing, for example, should be excluded, as they fall under the expenses of the household and not of the agricultural holding.

There are several cost items that directly or indirectly relate to land. Some are associated with owning the land such as property taxes or water rights, others to improvements such as water management (drainage or irrigation), fencing and road access, while yet other relate to the right to use the land itself.

When computing the CoP, all costs need to be accounted for. Still, in order to simplify the computations, it is advisable to separate the different land associated costs into classes that are treated in the same way. This suggests that land expenses that occur within a single production cycle be classified to and treated the same as other variable expenses. They might be labelled as other land related costs. An example of an expense item that could fall into this category would be water use charges.

Land improvements that will provide service to multiple production cycles should be classified as capital and treated accordingly. This would include farm buildings that are on the land as well as maintenance and improvements to the land that do not have a permanent life such as roads or irrigation systems. For those additions to land that are necessary for certain crops, such as tree planting for orchards, they should be treated as other pre-production costs (see 0). This
The treatment of land improvement expenses is in line with the new European system of Accounts (ESA 2010), which recommends the creation of one additional asset class to include land improvement actions, such as wells, terraces, etc. to match the corresponding investment flow on land improvement expenses. This new accounting rule will improve the consistency of the whole economic accounting framework for agriculture.

The third cost associated with land is the cost associated with the use of the land itself, which is computed differently if the land is rented or owned by the farm. The main valuation methods are presented and described below.

**1st best approach:** *Rented land* should be valued at the price actually paid by the farmer provided it is priced at fair market value. Because land rental agreements can take many forms, the determination of the rental price actually paid by the farmer is often a complex and context specific exercise. A common land rental agreement in both developed and developing countries requires the tenant to provide the land owner a portion of the crop as payment. In this situation, the value of the crop assigned to the landlord should be valued at the market price for the crop, *i.e.* the producer price. In Canada for example, farmers renting land on a “share crop” basis generally give one-third of their harvest to the land owner. This ratio varies according to characteristics such as the type of crop being cultivated, the region, the proximity of the land to urban centers, etc.

*Owned land* can be estimated using two main methods. The first one, theoretically appealing, is to estimate the opportunity cost for the farmer of holding the land, *i.e.* the foregone revenues to the operator had the value of the land be invested in its next best alternative. The market value of the land multiplied by the imputed interest rate reflects the cost to the farmer of using his land for agriculture rather than an alternative. A range of factors limit the actual applicability of this approach: first, determining the value of a given parcel of land is a complex exercise, in the frequent case of absence of a sufficient number of transactions for similar land from which to draw a representative market value. Second, the “next best investment alternative” and the corresponding rate of return depends on a number of characteristics which are very difficult and costly to capture and are very much context and judgment-specific. Often the annual rate of return for long term government bonds are used, but this is not optimal as it does not necessarily the range of returns of the possible alternative investments.
Given these limitations, the costs associated with the use of owned land can be approximated by the imputed rental price, i.e. the price that would be requested had the land parcel been available for rent. Prevailing rental rates in the region, locality or village for similar land can be used provided that a sufficiently deep rental market exists. This approach implicitly presumes that the cost to the farmer of using his owned land is equivalent to his cost had he rented the same land in the market place.

**Other approaches:** If a sufficiently robust rental market does not exist, then implicit rental costs can be estimated on the basis of the relationships between the rental value of land to characteristics such as the perceived quality of the land (orientation, slope, irrigation, etc.), its proximity to urban centers (which might increase its value), etc. Hedonic regressions such as these can provide meaningful and consistent estimates of rental values, especially in the absence of local rental markets from which representative prices could be drawn. But this approach requires detailed data on: land characteristics and rental values for a representative set of farms from which robust coefficients could be estimated; and on each land parcel and farm characteristics for which land costs need to be imputed.

**Specific measurement issues:** In some countries, rental agreements are subject to administrative regulations imposing pre-defined ceilings on rental rates. Where rental markets are inexistent or too thin to provide reliable estimates, these prices may be used to impute costs for *owned land*, with the risk of generating biases in the estimates if actual paid prices differ significantly from regulatory ceilings. In cases where observed rental fees are higher than the maximum imposed by the legislator, indicating a failure in the enforcement of the regulation, the question arises as to which rate to choose: using the actual rate paid by the farmer would better reflect the actual cost but would also lead to results inconsistent with the legislative requirements and would expose its lack of enforcement.

As with the case of labour, it is advisable to compute one estimate of land costs using official rates when rental fees are higher than official maximums and another one, for analytical purposes, based on observed paid rents.

**Example 1:** The farmer rents the land. The farm produces wheat on a 10 ha rented land. The annual rent is expressed as a percentage of the total wheat production during the cropping year, 25% in this case. As the farm produces annually 17 Metric tonnes (Mt) of wheat, 4.25 Mt are assigned to the land owner as payment. The value of wheat output reported by the farm during the survey was 10200 USD, i.e. an average unit price of 600 USD per Mt of wheat.
The annual rent paid by the farmer for the 10 ha of land can therefore be estimated at $4.25 \times 600 = 2550$ USD.

**Example 2:** The farmer is the owner of the land. The farmer owns a 5 ha plot of land where he grows chili pepper intercropped with coffee. The very few transactions involving agricultural land in the locality impede the use of market prices to value land and use interest-based methods. The usage in the locality is to provide a payment in-kind to the landlord, which, according to previous surveys, generally amounts to one third of the annual crop output. Given the output of the farm, 10 Mt for chili peppers and 3 Mt for coffee (green) and unit prices of 1400 USD/Mt and 4200 USD/Mt respectively, the imputed rent is: 

$$\frac{1}{3} \times (1400 \times 10) + \frac{1}{3} \times (4200 \times 3) = 8192$$ USD.

### 5.7 Pre-production costs

**Scope** Pre-production costs are those expenses that are incurred at least one year in advance of the time period when the commodity is actually produced and can be sold on the market. A more precise definition with respect to the time period in which these costs are incurred is provided in the AEAA Handbook: “The pre-productive period begins with the first expense associated with establishing the crop enterprise and ends in the crop year just before the crop yields a substantial percent of its expected mature yield (usually 70-80%)”. These expenses can be incurred for commodities that are produced or harvested entirely within a single year (single-year enterprise, e.g. trees) or over several years (multi-year enterprises, e.g. perennial crops, fruit tree, vineyard, dairy cows, etc.). To obtain relevant and comparable cost and revenue estimates, pre-production expenses need to be allocated to the year or years in which production takes place. All cost items (direct, indirect, labour, land, capital) should be included and estimated using the same methodologies than those described in the previous paragraphs.

Given the time difference between the moment costs are incurred and production effectively takes place (which can reach several years), it is essential for comparability and time consistency purposes to adjust nominal costs for inflation and, ideally, for the opportunity cost of capital. The production for the commodity and/or any joint product that takes place during the pre-productive years (e.g. banana trees planted on cacao plantations) should be recorded and deducted from the costs. More formally, pre-production expenses can be
calculated as the negative of the net returns during the pre-productive years adjusted to the end of the pre-productive period:

\[ PPC = \sum_{h=1}^{H} (1 + i)^{H-h}(-R_h) \]

where:

- \( PPC \) represents the total pre-production costs incurred in the pre-productive period
- \( H \) is the length in years of the pre-productive period
- \( i \) is the annual inflation rate (or a nominal interest rate, if the costs need to be adjusted for the opportunity cost of capital)
- \( R_h \) the net nominal return in year \( h \)

### Case 1: Production occurs entirely in a given year

**Approach:** The first step is to identify the beginning of the pre-productive period, i.e. the establishment costs associated with the production of the commodity. An example of establishment costs is the removal of old trees before the planting of new ones. All pre-production costs should be recorded and valued in current monetary units and adjusted for inflation to the reference period (e.g. the end of the production year). Ideally, the pre-production expenses should also be adjusted for the annual cost of carrying these expenses, i.e. the opportunity cost of capital (the return on capital if the funds had been invested elsewhere). The adjusted accumulated total is then simply charged against production at the time when the commodity are harvested.

### Case 2: Production extends over several years

In this situation, the pre-production costs need to be allocated to the years over which production takes place. Several approaches can be implemented, with varying degrees of complexity and data requirements.

**Traditional budgeting method:** According to this method, pre-production costs are allocated over the productive years using the same approach used to depreciate capital assets. Annual depreciation establishment expenses should include all capital and current expenses and are generally calculated using a
straight-line depreciation schedule:

\[ D = \frac{PPC - SV}{N - H} \]

where:

- \( D \) is the annual portion of the establishment cost that needs to be allocated to each productive years;
- \( N \) is the productive period in years of the enterprise; and
- \( SV \) is the enterprise value at the end of the production period (salvage value).

\( PPC \) and \( SV \) are expressed in prices referring to the last pre-productive year. The amounts charged to each production year need to be adjusted for inflation:

\[ D_t = D(1 + i)^t \text{ for all } t = 1, \ldots, N \] if a constant inflation rate is assumed for the production period.

This method is relatively straightforward and familiar to most analysts as it is often used to estimate capital depreciation. The drawback revolves around the selection a depreciation schedule (be it straight-line or something else) that reflects the actual changes in value.

**Cost Recovery (or Annuity) Approach** As in the traditional budgeting method, the cost recovery approach consists in accruing annual preproduction costs to a future value at the end of the pre-productive period and allocate this amount over the productive years of the enterprise. The difference resides in the fact that this accumulated total is amortized over the production period using an annuity formula. There is therefore no need to select a specific depreciation schedule. The opportunity cost of capital is reflected in the choice of the real interest rate in the annuity formula. The annuity is formally determined by:

\[ A = \frac{PPC - SV}{(1 + r)^{N-H}} \times \frac{1 - \frac{1}{(1 + r)^{N-H}}}{r} \]

As in the traditional budgeting approach, the amounts charged to each production year need to be adjusted for inflation: \( A_t = A(1 + i)^t \text{ for all } t = 1, \ldots, N \) if a constant inflation rate is assumed for the production period. This method should be preferred to the traditional budgeting approach under conditions of inflation (Watts and Helmer, 1981) and when flows occur overtime (Walker and Kletke), which is the case for example of establishment
costs for perennial crops.

**Approaches for farms operating in a steady-state or equilibrium:** The following methods may be used when the farm is assumed to be operating at equilibrium, characterized by a fixed asset base (number of planted ha, number of cattle heads, etc.), constant replacement rates (percentage of ha of new plantation, percentage of new cattle heads, etc.) and fixed relative establishment costs. These methods have the advantage that they are simple to calculate, but their main drawback is that they are really only relevant for steady state farm operations because of the implicit assumption of fixed technology and production practices.

The first of these methods is the *current cost approach*. It consists in determining pre-production costs as a share of current costs. This share is based on the determination of the steady state replacement rate for farm assets: 10% of a herd may need to be replaced annually to maintain stable the number of cattle heads, 25% of the land may need to be replanted annually to maintain a constant share of productive land (e.g. crops like alfalfa with a 1 year pre-productive period and 4 productive years).

Concretely, the calculations are done in 2 sequences. The first sequence consists in determining the ratio of pre-production costs to current costs, assumed to be fixed for a given time period under the assumption of fixed technology (steady-state or equilibrium): pre-production costs (PPC) are determined in the same way as previously described and current costs are simply measured as the value of assets bought at the beginning of the period minus the value of assets sold at the end of the period, plus the opportunity cost of assets bought at the beginning of the period and operating costs associated with these assets. This operation can be done with data spanning a sufficiently large time period (e.g. average of 3 years) to reduce the risk that “exceptional” might distort the ratio. The second sequence consists in applying this constant ratio to estimated annual current costs and the resulting amount is charged against production for the corresponding year.

**The Market Value approach:** This is very similar to the current cost method: the only difference is that the former estimates pre-production costs by the market value of the assets that are being produced. For example, market values for replacement animals will be used to estimate pre-production costs for a livestock farm, as opposed to actual costs associated with livestock breeding (land lease rates for land costs, etc.). This method is generally preferred to the current cost approach as it makes use of opportunity costs, which should be
used to better approximates.

This method is also easy to implement and particularly adapted for livestock preproduction expenses. A significant drawback to the use of the market value method is that markets might not exist or may be too thin to provide robust estimates, in which case the historic cost (or raised value) method may be used. Market valuations might also be biased towards future earnings and not historical costs.

**Example:** Estimation and allocation of pre-production costs for a 20 ha cocoa plantation. The following assumptions are made:

- Average yield for the productive years: 306 Kg of cacao beans per ha;
- Selling price: 4000 USD per metric ton;
- Annual inflation rate: 15%;
- Length of the pre-productive period: 4 years;
- Yield during the per-production period (as a percentage of the average yield for the productive years): 0% in the 1st year, 5% in the 2nd, 40% in the 3rd and 60% in the 4th;
- Average CoP for the productive years: 2.0 USD per Kg of cacao beans;
- Establishment costs (as a percentage of average CoP for the productive years): 270% in the 1st year, 110% in the 2nd, 105% in the 3rd and 100% in the 4th;
- Production period: 25 years

These assumptions enabled the following determination of the flow of returns and costs (Table 3) and net returns, including allocated establishment costs (Figure 13).

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22 See AEAA Handbook on Costs and Returns (2000), section 10-19, for further details on this approach.
23 Data and parameters used in this example are taken from a variety of sources (FAOSTAT, International Cocoa Organization, Camara Venezolana del Cacao, Gobernación del Huila in Colombia). The calculation and allocation of pre-production costs are the sole responsibility of the authors.
Table 3 – Pre-production costs for the cocoa plantation

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (ton)</th>
<th>Returns (USD, nominal)</th>
<th>Costs (USD, nominal)</th>
<th>Net returns (USD, nominal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
<td>0</td>
<td>33048</td>
<td>-33048</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
<td>1224</td>
<td>13464</td>
<td>-12240</td>
</tr>
<tr>
<td>3</td>
<td>2.4</td>
<td>9792</td>
<td>12852</td>
<td>-3060</td>
</tr>
<tr>
<td>4</td>
<td>3.7</td>
<td>14688</td>
<td>12240</td>
<td>2448</td>
</tr>
</tbody>
</table>

Note: Using the formula presented above, total pre-production costs are estimated as PPC = 67520 USD.

Figure 13 – Net returns with allocated establishment costs (USD per ha in nominal prices)

Date source: Multiple (FAOSTAT, International Cocoa Organization, etc.).
Box 7 – The dissemination of micro-level data – the USDA/ERS experience

Introduction

Micro-level data from USDA’s Agricultural Resource Management Survey (ARMS) are made available only to U.S. government agencies and academic researchers in U.S. institutions with approved projects with the Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS) that contribute to USDA’s public sector mission. This data access enables researchers from U.S. universities to complement and extend the research of ERS staff. In 2013, researchers at 24 U.S. universities were accessing micro data under this initiative. These projects are formally administered through agreements between ERS, NASS, and the responsible research organization.

Nature of information disseminated

Approved researchers obtain access to all variables from the questionnaire and all observations in the ARMS datasets once their project proposals are approved. The datasets remove personal identifiers, such as the respondent’s name and address, to comply with privacy legislation, and are available by year and commodity from 1991 to the present. ARMS summaries of farm-level data are released twice a year to the public through a web-based tool that allows users some flexibility in extracting tabulated and cross-tabulated data. This includes farm financial data, such as income statements, balance sheets and financial ratios, by specified farm and operator characteristics. Users can also obtain data on crop production practices, including chemical use, tillage use, and other practices, by specified farm characteristics. See: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx
Ensuring confidentiality of farm-level data
To ensure compliance with privacy laws, micro-data cannot be removed from approved USDA facilities, and before being publicly released, all statistical output generated by researchers must be vetted by NASS to protect against residual disclosure. As an additional step, all manuscripts must also pass a data disclosure check prior to publication.

ARMS weights are masked, which mitigate row, column, and page suppression, and masked weights are a form of randomisation. The data disclosure checks are based on minimum sample sizes where some statistics, such as maximums, are generally not permitted to be released.

Data discloser checks are automatically conducted on data summaries released through the public web-based data tool. In addition, summary data include the relative standard error (RSE) of estimates so users can evaluate the statistical precision of each estimate. Some estimates are suppressed by the data tool due to a combination of low sample size and a high RSE.
Conclusion and key challenges

This section will be completed in the final version of the Handbook.
References


Bureau for Food and Agricultural Policy (2012), *Farm Sectoral Determination: An Analysis of Agricultural Wages in South Africa*. South Africa: BFAP.


Ronzon, Tévécia et al. (2014). *Literature Review on Cost of Production Methodologies*. Forthcoming, European Commission Joint Research Centre and FAO.


Operations. Washington: USDA.
Annexes

Country-level Data Collection Questionnaires

**United States**

Comments: questionnaires are accompanied by booklets and manuals for interviewers and respondents; the 2012 Soybean questionnaire was 35 pages with sections on farm environmental practices (pest management practices, etc.), though no section on buildings (warehouses, etc.).

Link to the on-line questionnaires and related information:

**South Africa**

Comments: an income and expenditure survey; the scope is commercial farms registered in the taxation system; the statistical unit is the farming unit, which consists of one or more farms involved in cropping and/or livestock activities.

Link to the on-line questionnaire:

**Niger**

Comments: a questionnaire on livestock and agriculture, part of a broader survey on household living conditions; the statistical unit is the household; costs for the rainy season are distinguished from those in the “contre-saison”; there is a specific section on access to land.

Link to the on-line questionnaire:

**Nigeria**

Comments: a questionnaire on agricultural post-planting costs, part of the general household survey program; the statistical unit is the household; content covers crops and livestock with a section on agricultural by-products; labour costs are not specifically addressed.
Link to the on-line questionnaire (and related documents):
http://www.nigerianstat.gov.ng/nada/index.php/catalog/42/questionnaires
Glossary

**Average costs**

Total costs (variable and fixed) per unit of output produced (e.g. per ton of wheat, per thousands of liters of milk, etc.)

**Cash costs**

Inputs purchased by the farmer by direct cash payment (e.g. fertilizers, fuel, pesticides, etc.)

**Direct costs**

Costs which can be unequivocally attributed to the production of a given commodity (e.g., fertilizers, etc.)

**Farm enterprise**

Relates to one of the activities or commodities of the farm holding, to which a separable commodity production function can be assigned.

**Farm holding**

Administrative or fiscal unit to which agricultural production can be assigned, which may be a household or registered public or private farm company. Farm holdings can produce more than one agricultural commodity and may also be involved in non-agricultural secondary activities, such as tourism.

**Fixed costs**

Costs which can be considered as independent from the quantities produced (e.g. buildings and other infrastructures). Note: in the longer term, all cost items can be considered as variable, though costs can be fixed over a certain limited production range (e.g. additional harvesting machines must be bought when the crop area rises above a certain size, etc.)

**Indirect costs**

Cost shared by different commodity production processes or farm enterprises and which cannot be attributed unequivocally to each commodity.
**Inter-cropping**

Agricultural practice consisting in the growing of two or more crops in proximity. Mixed inter-cropping is the practice of growing different crops on the same piece of land, which is equivalent to mixed cropping; row inter-cropping means that different crops are arranged in different rows; relay inter-cropping is when different crops are sown and harvested at different times of the year to take into account different crop growing cycles and/or to maximize the combined yield.

**Joint outputs**

Outputs that share a common production technology. Examples of joint outputs include wool and sheep, and grain and straw.

**Marginal cost**

Cost of producing one additional unit of output (mathematically defined as the first derivative of the cost function with respect to the quantities produced).

**Mixed cropping**

Also known as multiple cropping, this agricultural practice consists with the growing of two or more crops simultaneously on the same piece of land. See also inter-cropping.

**Multi-year enterprise**

Farm activity for which the production cycle extends to more than one production period. These includes perennial crops and plants such as fruit trees, nut trees, cocoa and coffee trees, etc.

**Non-cash costs**

Inputs used by the farmer for which direct cash payments were not made (farm-produced inputs, unpaid family work, etc.)

**Opportunity costs**

Implicit benefit or revenue foregone due to an investment decision or input allocation. The opportunity costs resides in the determination of the baseline or alternative decision. Examples include the following: the opportunity cost of capital invested may equal revenue foregone had the same amount been
invested in long-term treasury bonds; the opportunity cost of farm family work may be determined by off-farm wages in the region.

**Representative (or typical, or average) farm approach**

Research approach used in agricultural economics to determine economic characteristics of farm, such as technical coefficients and farm profitability measures. This method is based on the construction of an hypothetical farm that represents the farm practices of a given area or for a given farm type. Farm characteristics of interest are generally determined for this hypothetical farm on the basis of discussions with experts comprising a panels of farmers, farm extension, workers, local experts, researchers, etc., from which an expert opinion or consensus emerges. Results generated from this approach should not be extrapolated to the population as a whole.

**Sampling frame**

Population set or universe from which samples are drawn. List frames are most commonly used (e.g. a list of households determined from censuses, or companies identified by their fiscal number, etc.), though alternatives include area frames, which may also be used in agriculture.

**Survey sampling**

Process of selection of a sub-set of the target population or universe on which the survey will be carried out. The selection of the sample may be based on random (probability sampling) or deterministic techniques (non-probability sampling). Probabilistic methods allow to select samples representative of the target population, which is a necessary condition if results obtained on the sample require extrapolation to the target population as a whole.

**Variable costs**

Costs which vary according to the quantities produced (fertilizers, seasonal labour, fuel, etc.).
Global Strategy to Improve Agricultural and Rural Statistics