HANDBOOK ON

Agricultural Cost of Production Statistics

Guidelines for Data Collection, Compilation and Dissemination

HANDBOOK ON

Agricultural Cost of Production Statistics

Guidelines for Data Collection, Compilation and Dissemination

February 2016

Contents

Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFCAS	African Commission on Agricultural Statistics
APCAS	Asia and Pacific Commission on Agricultural Statistics
ARMS	Agricultural Resource Management Survey
BAS	Bureau of Agricultural Statistics
BFAP	Bureau for Food and Agricultural Policy
CCCP	Cost of Cultivation of Principal Crops Surveys
CFS	Crop Forecasting Survey
CONAB	Compañía Nacional de Abastecimiento
CoP	Cost of Production
CRS	Costs and Returns Survey
CSO	Central Statistical Office
DESMOA	Directorate of Economics and Statistics in the Ministry of Agriculture of India
DFID	Department for International Development of the United Kingdom
ERS	Economic Research Service
ESA	European System of National and Regional Accounts
ESS	FAO Statistics Division
FADN	European Union Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nations
FCRS	Farm Costs and Returns Survey
FRA	Zambian Food Reserve Agency
FRKP	Farm Record Keeping Project
ICOP	Indonesian Cost of Production
IICA	Interamerican Institute of Cooperation on Agriculture
MACO	Zambian Ministry of Agriculture and Cooperatives
NAAS	United States National Agricultural Statistics Service
NFBS	National Food Balance Sheets
NSO	National Statistics Office
PHS	Post-Harvest Survey
SNA	System of National Accounts
UNSC	United Nations Statistical Commission
USDA	United States Department of Agriculture
WCA	FAO World Programme for the Census of Agriculture
ZMK	Zambian Kwacha

Preface

This version of the Handbook on Agricultural Cost of Production Statistics 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 and higher incomes, and improve the well-being of agricultural and rural populations through evidence-based policies. The Global Action Plan of the Global Strategy is centred on three 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 programme is scientifically sound and contains cost-effective methods that are used as inputs to prepare practical guidelines for use by country statisticians, training institutions and consultants, among others.

Economic performance indicators for agriculture are a fundamental requirement for improving market efficiency and decision-making. Statistics on agricultural costs of production have historically been among the most useful of such indicators.

This Handbook presents guidelines and recommendations for designing and implementing a statistical program on cost of production (CoP) in agriculture at the country level. It takes into account experiences from countries with existing programmes and findings of a recent review of relevant academic and policy literature. It acknowledges that countries differ with respect to their statistical infrastructure and their objectives, creating country-specific challenges. This Handbook may serve as a useful reference tool for agricultural statisticians and economists to build on or to adapt existing programmes 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, the Handbook also provides practical and context-specific guidance for countries on cost-efficient ways to produce high-quality and internationally comparable agricultural CoP statistics.

The Handbook has been updated with results from in-country field tests and based on feedback and experiences of countries. This Handbook is published under the Handbook and Guidelines Series.

Acknowledgements

<div style="text-align: right; color: orange; font-size: 4em;">1</div>

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. It is especially aimed at developing countries, which requested this document and actively contributed to its preparation.

This publication 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 should be considered when applying recommendations within this Handbook and taken from the Action Plan include the following:

- 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 labour, land use, and fishery and forestry production;
- Technical standards and guidelines for the coordination of agricultural censuses with population censuses; and
- Dissemination standards.

This Handbook is structured as follows: the second chapter presents the main uses and users of statistics on CoP; the third chapter focuses on the statistical outputs that can be expected from a programme on production costs; the fourth chapter provides the necessary general considerations on data collection methods, including, among them, surveys and censuses; the fifth chapter constitutes the core of this publication as it presents in detail the different recommended methods to compute the cost for the different items, such as cash and non-cash inputs, labour, land and capital; the sixth chapter provides general recommendations on how the data should be presented and disseminated, in accordance with international guidelines on the topic; and the seventh and final chapter concludes with a summary of the objectives of the Handbook and the process involved in drafting it.

2

Uses and benefits of cost of production statistics

2.1 INTRODUCTION

A sound statistical CoP programme 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 programme, 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 programmes 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 strives to identify and quantify the benefits from more complete, accurate and internationally comparable CoP statistics for the different users of this information. It also gives an indication of the costs of collecting and compiling this data which vary greatly depending on approaches and methodologies used.

2.2 FOR FARMERS AND AGRICULTURAL MARKETS

Cost of production statistics generally only benefit the data suppliers indirectly through improved policy-making, better administrative decisions and more efficient markets. However, there is also potential for the data supplier, namely the farmers themselves, to reap direct benefits.

At the farm level, CoP data contributes to improve the economic assessment of farm operation. They allow the producer to question his own operation and to benchmark it against the best practices of farms in the same region with similar characteristics. This, in turn, can lead to better informed decisions at the farm-level and improved market efficiency and performance. Some specific examples of how a robust CoP programme can be used at the farm level are as follows:

- **Enterprise mix decisions:** analysis can illustrate which farm enterprise (commodity) is positively contributing to the whole farm financial picture and lead to reallocation between enterprises, as appropriate.

- **Purchasing and marketing decisions:** pricing targets for inputs and outputs can be set at different cost break-even levels. Knowing the break-even points allows farmers and policy-makers to take advantage of growing, buying or selling opportunities when they arise. The following formulas can assist in determining break-even points.
  - Break-even price to cover variable costs (or gross margin): Total variable costs ÷ expected yield =USD/unit produced. This is the minimum price needed to cover variable costs
  - Break-even price to cover total costs (or net margin): Total costs ÷ expected yield = USD/unit produced. This is the minimum price needed to cover all costs.
  - Break-even yield: Total costs/expected price = unit produced (minimum yield required to cover all costs).
- **Investment decisions:** Making the right investments in capital assets, such as land, machinery and buildings, is critical to long-term success. CoP information shows the amount the farm can afford to pay for those assets. It is useful when conducting reviews of investments in enterprises that fail to meet total costs in the long run and determining where to redirect resources to more profitable enterprises.

Cost of production statistics provide 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.

Cumulative distribution curves on CoP provide an example of direct use by farmers of such data for benchmarking purposes. Farmers can use these graphs to compare, for example, their holding against holdings of a similar type. An illustration is provided below for the United States of America. Graph 2.1 presents data on the cumulative distribution of CoP for dairy farms in different regions of the United States. Using this graph enables individual farmers to compare, for instance, the costs of their production with median CoP for dairy products in the United States (about 10 USD/cwt[1] that is COP of the typical farm in the Fruitful Rim-West region), as well as any other dairy farm spending between 20 and 80 percent of the total dairy CoP in the country.

GRAPH 2.1
Regional cumulative distribution of milk operating and ownership costs, 2000
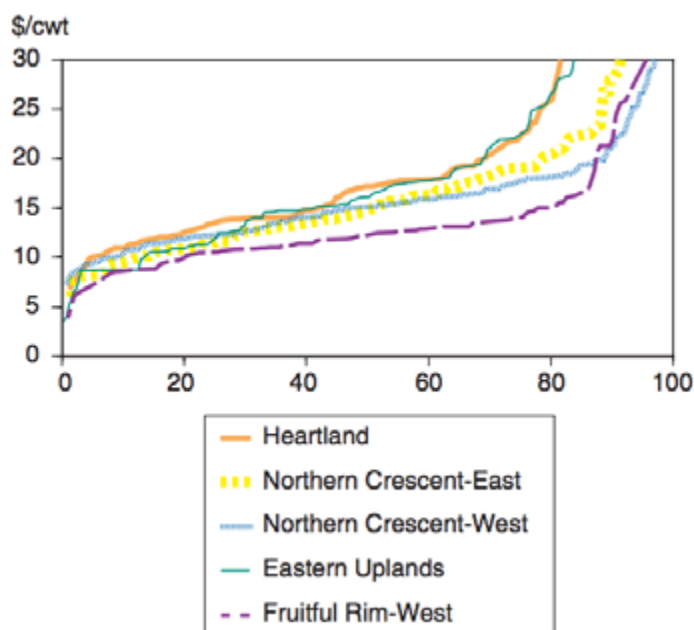
Source: Short 2004

---

1 Cwt, also known as a hundredweight, is a unit of measure used in the trading contracts of certain commodities in North America. It equals 100 pounds.

Farm-level CoP data enable 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, allows farmers to understand better how to improve the efficiency and profitability of their operations.

Graph 2.2 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 as it enables them to weigh the costs and benefits of such investments. However, it is only effective if detailed and accurate information on costs and revenues for the different types of operations are available and considered.

GRAPH 2.2
Net returns for Irrigated and Non-irrigated palay in the Philippines, 2012
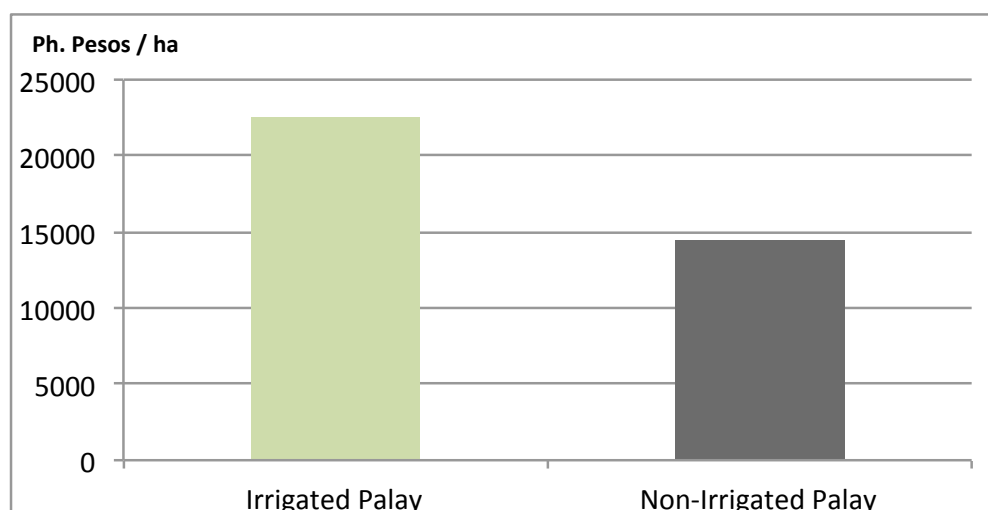
Source: Authors, based on data from CountryStat Philippines, 2014.

Finally, more complete and accurate statistics on CoP benefit 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, which are 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 products to farmers' needs at lower prices. The end result of improved access to financial credit by creditworthy farmers may, in turn, increase efficient investments in agriculture, resulting in higher agricultural output and productivity.

2.3 FOR POLICY-MAKERS AND GOVERNMENTS

Cost of production information is effectively used by policy-makers to improve the targeting and efficiency of agricultural policies. More complete data are needed to appropriately understand the underlying processes that influence the output and productivity of this sector, and how these processes are affected by new policies and regulations. For example, accurate CoP data allow a more precise determination of price formation and, therefore, assist 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. As agriculture is intertwined with households in much of the developing world, this data can help in determining income measures and support anti-poverty and food security policies.

In countries where price supports, investment aid, or import and export decisions are critical, having reliable and accurate CoP data helps to reduce the risk of overpaying or overspending for those programmes. Narrowing the range for income and price support typically reduces overpayments to such an extent that the survey programme can be funded out of better designed programmes. 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 overspending (Box 2.1). This example is an elaboration based on Burke *et al*. (2011).

Obtaining accurate return measurements for different crops and different types of production technologies are essential in designing public policies aimed at fostering greater efficiency in agricultural production. Graph 2.3 illustrates the net returns for peanut production in the Philippines, and how such returns have steadily increased since 2000. Public measurements in the agricultural sector, such as tax incentives, subsidies and minimum prices, can be adjusted and assessed effectively, based on this type of indicator.

BOX 2.1
Costs of ill-designed policies: the example of the maize price scheme in Zambia
In 2009 and 2010, the buying price offered by the Zambian Food Reserve Agency (FRA) for maize was 65,000 Zambian kwacha (ZMK) per 50 kg bag of maize grain, though 86 percent of farmers actually produced the crop at a lower cost (the mean CoP was 40,739 ZMK) (Burke *et al.* 2011). 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 overspending generated by the scheme because of the existing buying price. Taking the average production cost of 40,739 ZMK as the new buying price, the overspending 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 results in a slight overestimation, given that the curvature of the function is neglected. Using this approach, the cost or over spending is estimated at approximately USD 107 million for one year of the total scheme (see the table below for details). Of course, a different buying price could have been chosen leading to different estimates, but this example only intends to provide an illustration of the magnitude of the recurrent and does not attempt to present perfectly accurate estimate.

Estimations of over spending in the maize price scheme in Zambia, in USD

In USD*	50 kg bag	Million MT	Quantities (Million MT)
Buying price FRA	14.3	285,714 (A)	2.06 (C)
New buying Price	9.0	179,073 (B)	1.6 (D)
In USD*	B*(C- D)	(A-B)*(C-D)/2	Total
Overspending (implicit cost)	USD 82,373,363	USD 24,527,604	USD 106,900,967
**Assumption: 1 USUSD= 4550 ZMK in 2010			

Distribution of maize production costs vs. official buying price in Zambia
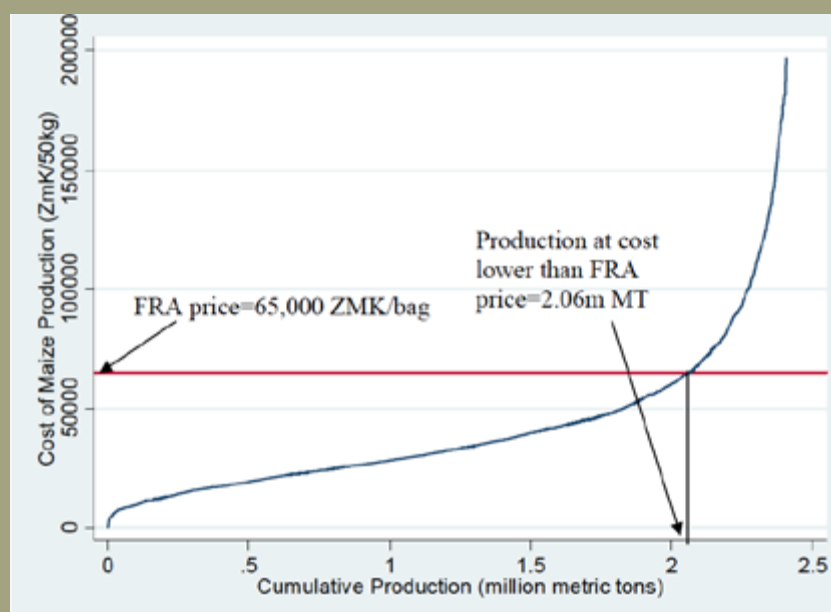
Source: authors, Burke *et al.*

Obtaining accurate return measurements for different crops and different types of production technologies are essential in designing public policies aimed at fostering greater efficiency in agricultural production. Graph 2.3 illustrates the net returns for peanut production in the Philippines, and how such returns have steadily increased since 2000. Public measurements in the agricultural sector, such as tax incentives, subsidies and minimum prices, can be adjusted and assessed effectively, based on this type of indicator.

GRAPH 2.3
Net returns for Irrigated and Non-irrigated palay in the Philippines, 2012
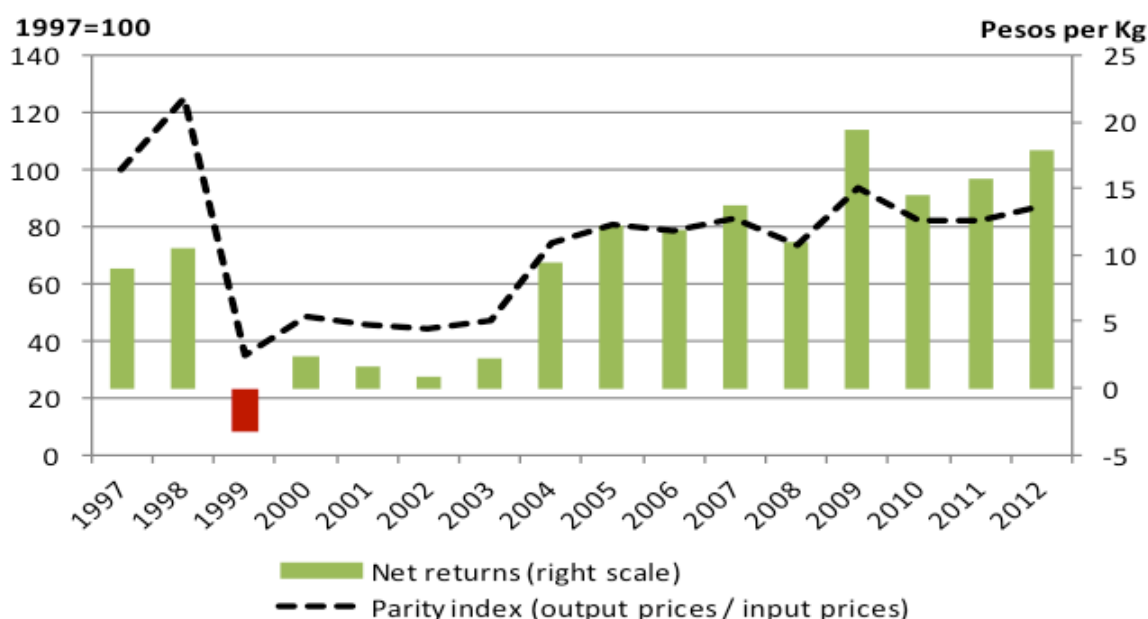
Source: Authors, based on data from CountryStat Philippines, 2014.

2.4 FOR THE SYSTEM OF NATIONAL ACCOUNTS

A properly designed national CoP data programme 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 are 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 a sector that is unavailable in the broader SNA. Figure 2.1 illustrates this sequence of accounts.

FIGURE 2.1
Sequence of national accounts and importance of cost of production statistics

Production Account	
+	-
Net value added	Wages
Subsidies on production	Taxes on production
Balance	Net Operating Surplus

Operating Account	
+	-
Production	Intermediate consumption
	Consumption of fixed capital
Balance	Net value-added

Income account	
+	-
Net operating surplus	Interest charges
	Rental expenses
Balance	Net Income of the Farm

Source: Authors, 2014.

Finally, the cost estimation of each of the main agricultural activities requires detailed data on input uses and costs by activity. These technical coefficients[2] can 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.

Graph 2.4 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 is 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 are also produced by farmers.

---

2   Amount of input per unit of output.

GRAPH 2.4
Cost structure for different commodities in the Philippines, 2012

Legend: Fertilizers, Pesticides, Labour, Fuel and oil, Repairs, Land, Depreciation, Seeds
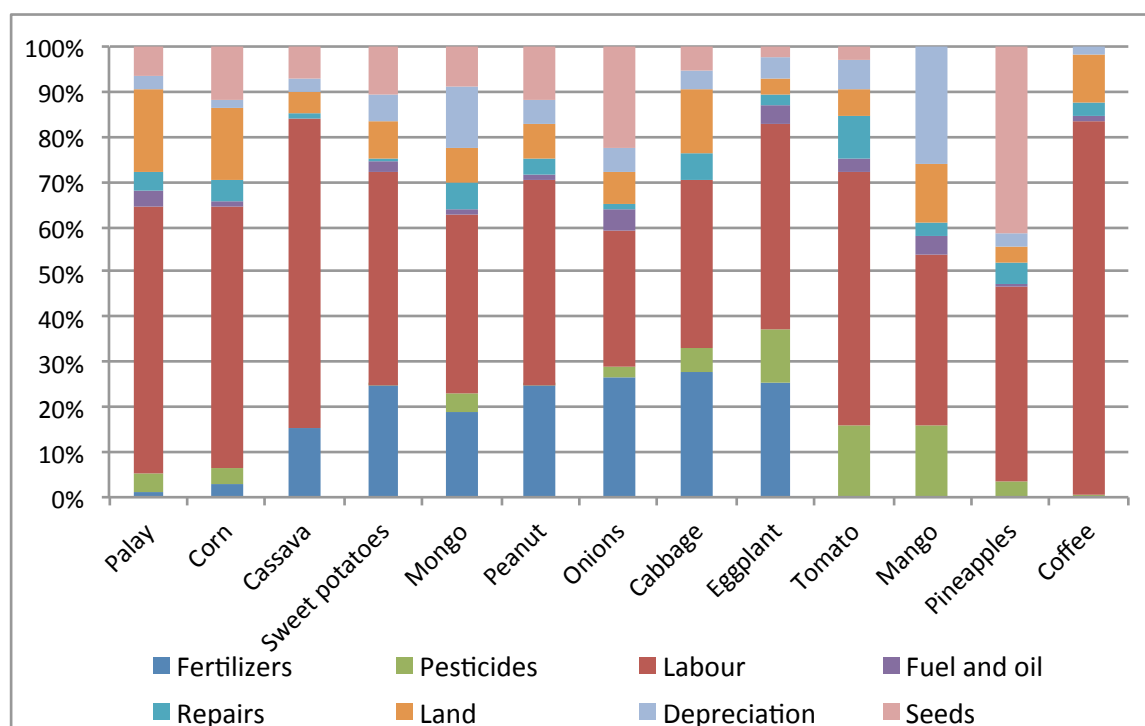
Source: Authors, based on data from CountryStat Philippines, 2014.

2.5 FOR RESEARCH

A CoP data programme can also support research on a variety of issues concerning commodity production. In the United States, where the CoP data programme dates back to the 1970's, those data have been used to study issues pertaining to the structure and productivity of commodity production, and the adoption of production practices and technologies among commodity producers. In this section, a few examples of the research generated from the United States data programme are presented. Undertaking research about commodity issues important to individual countries is a way to increase the return to the often costly and time-consuming process of CoP data collection and processing, especially when extensive farm surveys are conducted.

The most common presentations of research from the United States CoP data are reports describing the characteristics and production costs of specific commodity producers (Foreman, 2012). These reports examine how production costs vary among producers of different commodities. They include details on production practices and input use levels, such as the technology set, as well as farm operator and structural characteristics that underlie the cost of production estimates. The reports also illustrate the degree to which costs vary for producers of different commodities and indicate possible reasons for the variation. Characteristics and production costs are presented for low- and high-cost producers of each commodity, and producers of varying size, region, and typology classification.

United States CoP data have also been used to study changes over time in the productivity of commodity production. McBride & Key (2013) monitored changes in structure, technology, and productivity in the United States hog industry from 1992 to 2009. In this research CoP data, along with other farm and commodity production data, were used to describe how structural change contributed to substantial productivity gains for hog farms, which benefited

United States consumers by resulting in lower pork prices and enhancing the competitive position of the producers in international markets. These gains, however, have come with increased environmental risks from concentrating hog production and manure on a smaller land area.

Special CoP surveys of organic commodity producers in the United States have been used to describe the structure and costs of organic milk, soybean, corn, and wheat production, and to compare them with non-organic systems (USDA, Economic Research Service-ERS). In-depth research on organic dairies has revealed that pasture dairies had lower average milk production per cow and higher per unit production costs than other organic dairies (McBride and Greene, 2009a). This suggests that organic dairies using confinement systems similar to most non-organic dairies were more likely to generate higher returns than pasture dairies. From a policy perspective, this means that interpretation and implementation of organic farm pasture requirements could have a major impact on the sizes and type of farms able to produce certified organic milk.

3

Statistical outputs, indicators and analytical framework

3.1 INTRODUCTION

The best data are meaningless without putting them in context, which often involves defining an analytical framework as the basis for the work. As there is no perfect analytical framework, this Handbook does not suggest a one-size-fits-all approach, but instead it gives a list of non-exhaustive examples of statistical indicators drawing on experiences from countries with well-established CoP programmes. It also provides key principles on how to interpret indicators and statistical outputs and how to assess their quality in order to give credence, confidence and respect to ensuing analyses and subsequent conclusions. Before producing indicators, the statistician must consider the choice of the unit (or normalization factor) in which the different measures of costs and profitability are to be expressed as well as the dimensions of the production costs to be included.

3.2 DIFFERENT DIMENSIONS OF PRODUCTION COSTS

The type of CoP indicators and outputs that can be produced depends on a series of factors, such as their intended use and the audience to which they are aimed. The data collection vehicle used as well as the underlying quality and level of detail available from farm-level data will also shape the analytical framework. Data drawn from representative farm surveys may be used to construct regional or national averages, while constructing indicators using non-representative data collections will likely result in misleading information and conclusions. To increase the relevance of CoP estimation to multiple users, different measures 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 3.1 illustrates how production costs can be partitioned into useful components and dimensions to meet some of these needs.

FIGURE 3.1
Different dimensions and segmentations of cost of production

Total costs = Variable costs + Fixed costs		
	Cash costs	**Capital costs**
	Purchased seed, feed fertilizers, etc.	Depreciation costs and opportunity costs of capital on owned machinery, buildings and farm equipment
	Paid labour	
	Custom services (machinery, etc.)	
	Non Cash Costs	**Farm overhead costs**
		Unallocated fixed costs
		Farm – level taxes, permits licenses, etc.
	Unpaid family labour	**Land Costs**
	Farm- produced inputs	Land rents and imputed rents, land related taxes
	Owned animals and machinery	

Source: Authors, 2014.

Countries can introduce additional distinctions based on the methodology used to compute costs and local practice. Some countries that disseminate CoP estimates distinguish between costs that are directly reported by the respondent during farm-level data collection and costs that are derived using approximations or were imputed. Imputed costs include all non-cash costs and any cost item for which unit prices are not available, either because the input was owned by the farm and no cash transaction took place or the information required was unavailable.

3.3 NORMALIZING THE ANALYTICAL UNIT

The unit of analysis for which the statistical indicators are to be presented must be standardized so that a meaningful interpretation can be made. The chosen unit is dependent on the type of farm activity, should also make sense from an economic point of view, be consistent with the unit used to value production and be understandable and usable by farmers, analysts and other persons interested in farm economics. Local or customary units, such as the number of bags of a certain weight or volume, may be selected if that is what is commonly understood in the local market place. For international comparisons, it is useful to convert these units to be in accordance with the units that are traded in commodity markets.

Land (area) units

A land unit is commonly used for presenting CoP for cropping activities. Planted area, harvested area or total land area can be chosen, depending on the context in the country. If there is an agronomic and economic rationale for leaving part of the land unexploited, such as the case of specific crop rotations, total land area should be used to reflect the production technology of the activity. The land unit should also be defined in relation to the standards managed in the region or country: hectares (ha) or acres, for example. Costs can be expressed on a per ha basis, or subsequent multiples, such as 1000 ha, if this better reflects regional or national characteristics, such as average farm size. The cost per unit of 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.

Production (volume or mass) units

Describing CoP using production measures is commonly used for crop and livestock products. While the normalization by land units better reflects differences with respect to technologies of production, costs expressed

on a per unit of production provides a more direct measure of the profitability of the farm. For cropping activities, the production unit that is commonly known and understood by the market can be used. Examples include 50 kg bags of maize (Zambia) or 50 kg bags of cacao beans (Colombia). Converting costs expressed in local units to 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 data across herd sizes, costs can be expressed in appropriate multiples, such as 100 or 1000 head. The MT can be used to express costs in live weight equivalents or a weight that is closer to the average animal weight, such as 250 kg for a calf. Similar principles can be applied to express costs of livestock products, such as the cost per 1000 litres of fresh milk or the cost of producing 100 eggs.

Value (currency) units

Indicators using values provide direct measures on the profitability and relative competitiveness of the farm operations. Expressing the cost required to produce a certain value of sales measures the share of costs in gross revenues or returns. This indicator must be consistent with the unit chosen for the output quantities. For example, 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 are more stable than residual indicators[3] as they have fewer dimensions. This makes interpreting the results correspondingly simpler, but can also limit the conclusions drawn..

3.4 INDICATORS AND STATISTICAL TABLES

Although many indicators can be developed and presented, several common examples are noted below. They are grouped by indicator type.

3.4.1 Economic indicators

a. **Total Costs per unit of production or unit of land area (depending on the product)**
   Defined as: *[Cash-costs + non-cash costs + land costs + capital costs (replacement and opportunity cost of capital) + farm overhead expenses] / Total land area in ha*.
   This indicator can also be expressed in terms of total area planted or operated, weight or volume of product, animal head for livestock activities or any other unit of relevance, especially local or customary units.
   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 are available, indicators are often displayed for individual cost items, such as feed costs per animal unit, seed cost per land area or labour cost per MT of output quantity.

b. **Net returns per measure of production (or net margin).**
   Defined as: *[Value of output – total Costs] / MT of output*.
   The unit in which total returns are expressed can be chosen among the ones presented above, depending on the type of activity, regional or national standards or audience targeted.
   Subsets of this indicator can be displayed, such as returns over cash-costs (gross margin), returns over cash and non-cash costs, returns over cash and land costs.

c. **Break-even price per unit of production**
   Defined as: *Total Costs / Total production*.

---

3 These indicators are those obtained by difference or deduction from two (or more) indicators. For example, food consumption in food balance sheets.

This measure indicates the market price necessary to cover one unit of production. The cost variable should reflect all (total economic) costs and the production unit should reflect only the marketable output by excluding waste. This ratio represents the "break-even" price or the price to cover the production cost for one unit of product. If unit farm-gate prices are higher than the break-even 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.

3.4.2 Environmental indicators

A wide range of indicators that relate farm activity to environmental variables can be compiled. These indicators can 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 shifting to less input-intensive practices. Some of these indicators are described below.

a. **Energy use per hectare**

Defined as: *[Fuel and lubricants use + electricity use] / Land area*.

This indicator can also be expressed in terms of production unit. The energy used could be converted to standard energy units, such as joules, or 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.

b. **Fertilizer use per hectare**

Defined as: *[Fertilizer use] / 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, such as manure, may also be included.

c. **Pesticide use per hectare**

Defined as: *[Pesticide use] / Land area*.

The comments made for the fertilizer use indicator also apply for this indicator.

d. **Environmental Pressure Index**

Defined as: *[Input use x emission factor]* / 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 publishing similar indicators, but on the basis of data compiled from sources such as including industry organizations and governments, which do not necessarily reflect the quantities of inputs used at the farm-level.[4]

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 statistics contribute to measuring and identifying the structural changes taking place in agriculture, in which, for example, higher returns on fixed capital are a well-known feature of more sophisticated production technologies.

e. **Input productivity**

Defined as: *[Value of output] / 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).

---

4 These indicators are available from the FAOSTAT Emissions Agriculture database.

3.5 INDICATORS AND STATISTICAL TABLES: SOME COUNTRY EXAMPLES

Zambia

Table 3.1 below shows a sample table taken from Burke *et al*. (2011).The table depicts the average cost of production by quintiles of maize cost of production by smallholder maize producers in Zambia. In the table, local classifications and units are adopted, such as basal dressing and top dressing and a 50kg bag is used for the unit of analysis, which is also commonly used and understood in Zambia. Costs are depicted at a medium level of disaggregation with cash costs added 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.

TABLE 3.1
Maize production costs (ZMK/50kg bag) by quintile

Share of total maize production (%)	Total cost quintile (ZMK/50 maize kg)					farmer mean	per 50kg bag mean
	1	**2**	**3**	**4**	**5**		
	31.4%	**27.1%**	**20.1%**	**12.8%**	**8.7%**		
Costs of production (ZMK/50kg)				**Mean**			
Hired animal use	283	516	829	1,163	1,763	911	536
Hired machine/tractor use	22	57	49	153	103	77	97
Hired labour	1, 493	2,662	3,340	4,825	6,619	3,788	3,438
Basal dressing[a]	1,314	2, 479	2,897	3,549	4,419	2,932	3,487
Top dressing[a]	1,290	2, 585	2,964	3,863	4,627	3,066	3,576
Fertilizer transport to homestead	39	108	143	184	223	139	193
Transport cost to FRA depot	349	606	407	296	208	373	763
Transport cost to private buyer	189	365	543	544	997	528	2,044
Herbicides	15	24	63	17	46	33	62
Seeds[a]	1,417	2,838	3,734	4,853	8,478	4,265	4,434
Total cash expenditures	**6,411**	**12, 239**	**14,969**	**19,449**	**27,482**	**16,111**	**18,630**
Family labour	8,274	15,379	25,585	41,810	87,103	35,638	19,745
Own animal use	873	1,431	2,179	3,071	4,287	2,368	2,304
Own machine use	9	29	43	12	82	35	61
Expenditures plus household labour and assets (excl. land)	**15,567**	**29,078**	**42,776**	**64,341**	**118,953**	**54,152**	**40,739**
Land annual rental	3,364	4,835	6,633	9,152	15,102	7,818	4,720
Total cost (incl. land cost)	**18,931**	**33,914**	**49,409**	**73,493**	**134,055**	**61, 970**	**45,459**

Source: Burke et al. (2011).
[a]Fertilizer and seed costs include both subsidized and commercially acquired inputs.

Philippines

Table 3.2 presents a sample output table for palay from the Philippines. Costs are illustrated slightly differently from the Zambian example. Imputed costs are displayed separately from cash and non-cash costs. Imputed costs refer to the cost of owned inputs whereas non-cash costs refer to those costs for which no monetary transactions has taken place, such as in-kind payments and transfers. Costs are displayed on a per ha basis for the two growing seasons as well as for the annual average. The cost per kg of output is only provided for total costs, not for individual cost items. Data are provided on input values and quantities and a series of derived indicators are compiled, including total costs, returns above cash costs (gross returns) and net returns.

TABLE 3.2
Costs and returns for palay (Philippine pesos) – Extracts

Descripcion		Unit	January - June		July - November		Average	
			Quantity	Value ($)	Quantity	Value ($)	Quantity	Value ($)
Production (A)		kg	3,499.71	N/A	3,280.22	N/A	3,408.94	N/A
Area harvested		ha	0.98	N/A	0.95	N/A	0.97	N/A
Number of sampled Farms		Unit	4,302	N/A	3,142	N/A	7,444[5]	N/A
Cash costs ($) (B)		**ha**	**N/A**	**16,610**	**N/A**	**14,846**	**N/A**	**15,881**
Seeds		kg	36.80	837	36.30	765	36.60	807
Organic fertilizer	Solid	kg	13.24	49	9.49	33	11.69	42
	Liquid	l	0.57	10	0.07	15	0.36	12
Inorganic fertilizer	Solid	kg	202.29	4,686	193.68	3,758	198.73	4,302
	Liquid	l	0.08	21	0.06	18	0.07	20
Non-cash costs ($) (C)		**ha**	**N/A**	**13,882**	**N/A**	**11,872**	**N/A**	**13,051**
Seeds		kg	43.34	675	56.67	888	48.86	763
Organic fertilizer	Solid	kg	9.40	18	7.95	12	8.80	16
	Liquid	l	a/	c/	0.02	c/	0.01	c/
Inorganic fertilizer	Solid	kg	0.59	16	0.80	17	0.67	16
Pesticides	Solid	kg	b/	c/	b/	c/	b/	c/
	Liquid	l	a/	c/	a/	3	a/	1
Imputed costs ($) (D)		**N/A**	**N/A**	**8,815**	**N/A**	**8,743**	**N/A**	**8,785**
Seeds		kg	16.37	363	16.53	314	16.43	343
Organic fertilizer	Solid	kg	2.61	14	17.26	10	8.67	12
	Liquid	l	0.01	2	a/	1	0.01	2
Inorganic fertilizer	Solid	kg	6.55	144	1.01	20	4.26	93
	Liquid	l	0.01	3	a/	c/	0.01	2
Total costs ($) (E) (B+C+D)		**$/ha**	**N/A**	**39,307**	**N/A**	**35,460**	**N/A**	**37 ,716**
Gross returns (F)		$/ha	N/A	53,773	N/A	45,434	N/A	50,324
Return above cash costs (B-F)		$/ha	N/A	37,162	N/A	30,588	N/A	34,444
Returns above cash and non-– cash costs (B+C)-F		$/ha	N/A	23,280	N/A	18,717	N/A	21,393
Net returns (G) (F-E)		$/ha	N/A	14,464	N/A	9,974	N/A	12,608
Net profit – cost ratio (G/E)		$/ha	N/A	0.37	N/A	0.28	N/A	0.33
Cost per kilogram (A/E)		$/kg	N/A	11.23	N/A	10.81	N/A	11.06

Source: Philippines, 2011.
[a]less than 0.01 Li.
[b]less than 0.01 kg.
[c]less than one (1) peso
N/A Not apply

---

5 Number of farms selected .

United States

Table 3.3 provides an example of a costs and returns table for corn production in the United States. In this example, costs and returns are presented on a per acre basis. The table denotes national-level data. Statistics are available for the main corn-producing regions as well.

The groupings of cost items differ from the examples presented above and estimates for family labour, allocated overhead costs, capital recovery for machinery and equipment are explicitly made available, along with estimates for owner supplied management and administrative labour. The list of cost items largely illustrates the differences in production technologies. Complementary information is provided on 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 (gross returns) and returns over total costs (net returns).

TABLE 3.3
Corn production costs and returns per planted acre in the United States, 2011-2012

Ítem	United States	
	2011 (USD/acre)	2012 (USD/acre)
Gross value of production		
Primary product: corn grain	836.58	800.04
Secondary product: corn silage	1.19	1.33
Total, gross value of production	837.77	801.37
Operating costs:		
Seed	84.37	92.04
Fertilizer 2/	147.36	157.59
Chemicals	26.35	27.66
Custom operations 3/	16.77	17.05
Fuel , lube, and electricity	32.42	30.78
Repairs	24.79	25.49
Purchased irrigation water	0.10	0.11
Interest on operating capital	0.17	0.23
Total, operating costs	332.33	350.95
Allocated overhead:		
Hired labour	2.92	3.04
Opportunity cost of unpaid labour	22.77	23.80
Capital recovery of machinery and equipment	89.59	94.35
Opportunity cost of land (rental rate)	138.20	154.94
Taxes and insurance	8.92	9.32
General farm overhead	18.73	-
Total, costs listed	281.13	304.84
Value of production less total costs listed	224.31	145.58
Value of production less operating costs	505.44	450.42
Supporting information:		
Yield (bushels per planted acre)	146	118
Price (dollars per bushel at harvest)	5.73	6.78
Enterprise size (planted acres) 1/	280	280
Production practices: 1/		
Irrigated (percent)	11	11
Dryland (percent)	89	89

Source: USDA/ERS, 2014.

These examples are meant to illustrate the diversity with which statistics on CoP can be presented. This diversity is the result of a multitude of factors, some of which are related to the commodity studied, the level of economic development of the country or region, the sophistication of its agricultural production and the social, cultural and religious conditions prevailing in the country.

3.6 DISSEMINATION AND INTERPRETATION OF STATISTICAL OUTPUTS AND INDICATORS

3.6.1 Coping with the variability in cost of production statistics

Data and statistical indicators on agricultural costs and returns vary considerably across farms because of agro-ecological factors, location, farming practices, farm characteristics, such as size, type of commodities produced and farm organization. The variations in farm practices and organization suggest that level or absolute estimates for cost of production might be less informative than providing information on the distributions of production costs across farmers (Burke *et al.*, 2011).

For these reasons, it is recommended that national and regional averages be accompanied with more detailed information on the distribution of costs across farmers. For example, costs broken-down by quartiles, quintiles, or deciles can be displayed as shown in Table 3.1. Plotting the full distribution or cumulative distribution of farms is even better (Box 3.1), as this presentation informs users (including farmers) on the profitability of their operation 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 taking into consideration the key drivers of the farmers' costs and returns. As these groupings are likely to be more homogeneous with respect to the key drivers, average costs will be easier to interpret and to compare across farm types. An interesting example is given in Box 3.1, which contains a description of how farms groups are defined in Morocco.

BOX 3.1
Construction of farm typologies – The example of Morocco
Introduction
Presenting data for groups of farms homogenous with respect to the key factor determining economic performance, such as farm specialization and size, simplifies the comparative analysis and evaluation. For example, the economic or environmental impact of innovative farm practices is better assessed for groups of farms that are expected to behave in a similar way to changes in their input structure, such as those that have similar production technologies.

Process of construction of farm classes
Cereals are the major basic food commodity of Morocco. National production covers up to 75 percent of consumption, depending on rainfall levels. Five classes were determined for the Mekens region 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 percent of the average yield;

Class III: area between 5-50 ha and yields higher than 55 percent of the average yield;

Class IV: area above 50 ha;

Class V: area above 50 ha and an irrigated area of more than 20 percent

Uses of farm classes
Constructing farm classes is crucial for resource allocation in Morocco, 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, namely USD/ton, and structure, namely technical coefficients.
Agricultural production planning aimed at characterizing production models requires that data be gathered and compiled for technical and economic indicators across different farm types and geographical areas.

Source: Ministry of Agriculture of Morocco, 2014.

3.7 ENSURING AND MEASURING QUALITY IN COST OF PRODUCTION STATISTICS

Statistical quality has several dimensions[6], of which three are of specific interest to CoP programmes. Below is a brief description of these three dimensions together with proposals on how to measure or assess them.

Relevance measures the extent to which compiled statistics meet the demands of data users, analysts and policy-makers. In this context, relevance depends on 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 through the following: Will the data be used essentially for policy purposes, such as the setting of price support schemes? Are microdata available for researchers and academics? And are the data essential for the compilation of other statistics, such as the National Accounts for Agriculture? The answer to those questions will, to a large extent, be related to the CoP programme, especially in terms of product or commodity coverage, level of details and data collection frequency. These scoping studies should be conducted at least every five years to ensure that the programme meets the needs of existing and emerging policy objectives and

---

6   United Nations guidelines on National Quality Assurance Frameworks provide more comprehensive information on quality assurance frameworks developed by national and international organizations, as well at the process to follow to carry out a proper quality assessment.

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 determines its relevance.

Accuracy is 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 generally unknown. However, it is good practice to provide information that gives an indication of the possible size and direction of the bias. This can include estimates of under or over-coverage of specific items (commodity, farm-type) that are likely to lead to an estimation bias and the choice of the survey period, which might lead to recall bias. Sources of bias should be: minimized to the extent possible ex-ante, when designing and carrying out the survey, such as stratification; and reduced ex-post by appropriate techniques such as ex-post stratification, estimation of totals or averages using auxiliary variables, when available. As an example, the tendency for farmers to over-report their labour use is a bias that can be minimized by using better worded questions and/or by correcting or scaling raw figures reported by farmers.

Precision + uncertainty measurements indicate the degree of confidence placed in the estimates. 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 CoP estimates. Chapter 4 reviews the different sources of errors associated with surveys, the main data collection vehicle for gathering data on CoP and the sources impact on the precision of the estimates. There are several ways to measure or take into account the uncertainty, which extends beyond the measurement of variances resulting from sampling errors. For example, the observed variance or standard deviation for any given cost item, such as total costs and non-specific costs, can be calculated for homogeneous subgroups. In addition to the final estimate, upper and lower bounds based on the observed standard deviation can be provided, for example, estimate + or – 2 standard deviations. Presenting the full distribution of the estimate within the population of interest and presenting the results according to deciles, quintiles or any other relevant population breakdown, including farm size and farm type, are very powerful tools for assessing the variability of the underlying estimates.

3.8 SUMMARY AND RECOMMENDATIONS

In this section, different ways of presenting data and indicators on CoP have been 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, suggestions are given 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 information, some guiding principles can be provided on what CoP data and statistical indicators should be disseminated and how they should be displayed. This Handbook does not suggest that one approach be followed, but it gives general recommendations that can be adapted to each country according to the countries context.

The recommendations are listed below:
• Variable and fixed costs should be disseminated separately;
• Costs for individual items or subgroup of items should be displayed when reliable data are available;
• The unit of normalization should be relevant for the commodity analysed and understandable by users, with examples for crops being acres, bags and kg;
• If possible, data on output quantities and values should be shown 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 and returns over total costs excluding imputed costs for owned inputs;
- Data for different regional groupings and size (or profitability or cost classes) should be compiled and displayed to take into account the distribution in costs across these groupings and classes;
- When possible, costs should be displayed by quintiles, deciles, or a similar measure, 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 subgroups displayed;
- Potential sources of biases should be identified and, when possible, the direction of the bias and its magnitude should be given.

4

Considerations for data collection

4.1 INTRODUCTION

The uses and purposes of the CoP programme should directly determine the nature and characteristics of the data collection phase. The data collection phase must provide the required data along with the appropriate properties, including, for example, coverage, representativeness and timeliness, necessary to compile the indicators and statistical outputs to be monitored by farmers, participants in the agricultural and food value chains, policy-makers and analysts. In figure 4.1, this process is described in a simplified diagram.

This section does not propose a single approach to the way data should be collected, but instead, it identifies and describes different possibilities with indications on how this affects, 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 programmes, applying a mix of survey and administrative data sources, such as administered prices and taxes, as indicated by the responses of countries to the 2012 FAO questionnaire on country practices[7]. Combining different data sources can help reduce the overall cost of data collection and may also contribute to improving data quality and small area detail.

---

7 A synthesis of responses to the CoP survey on country practices is presented in Annex 4.

Definition of the NEEDS

Improve commodity specialization, identify efficient farming practices, better targeting of monetary transfers, measure pollution abatement costs

Size of the BUDGET

Determination of the DATA COLLECTION STRATEGY

Sample survey vs. other approaches, stratification, size of the sample, periodicity of the data collection

Recordkeeping practices and level of literacy of the respondent

Definition of the OUTPUTS and INDICATORS

Total variable costs, Total cash costs, Net returns per hectare Examples of characteristics/ properties required:
- **Level of precision and accuracy**
- **Breakdown by activity, by farm type, agro-climatic area, Frequency**

Level and maturity of the Statistical infrastructure

Sources: Authors, 2014.

4.2 DATA COLLECTION VEHICLES

4.2.1 General considerations

Design of the data collection vehicle can only begin after first analysing and taking into account the many factors that will have a bearing on the design. The main influences as illustrated in Figure 4.1 are user needs, the financial constraints, and the infrastructure of the statistical agency.

Factors to consider when defining needs include:
- A thorough understanding of how the data will be used so that clear specifications can be articulated. This is accomplished in consultation with the client and data users;
- An understanding of the nature of the policy issues that are to be addressed by the project. The collection strategy will be for data used to simply describe the current situation as compared with data used to analyse relationships; the type of decisions that will be made by using the data and the consequences of error;
- If possible, potential respondents should also be consulted as they can identify issues and concerns that are relevant to them. Their input could affect the questionnaire content and collection strategies;
- User needs affect the collection objectives. If national support policies are the anticipated outcome of the project, then it follows that the precision of the estimates have to be elevated. If regional policies are to be designed, then it follows that the collection vehicle contains a regional dimension. Constraints such as these will have an effect on the chosen collection vehicle.

Factors affecting precision and the data collection vehicle include the following:
- The variability of the characteristic of interest in the population;
- The size of the population;
- The sample design and method of estimation;
- The expected response rate.

Operationally, the following factors also influence the design:
- The size of the sample required and the budgetary implications;
- The possibility of measuring the required variables with the available techniques;
- Will acquiring the desired results be too much of a burden on the respondents?
- The amount of time available for development work;
- The amount of time available to conduct the entire survey;
- How quickly are the results required after collection?
- The number of interviewers required and available;
- Can the collection infrastructure accommodate the chosen design and is there sufficient support staff available?

In determining the content and approach to data, it is often useful to form and consult with an external advisory committee of experts and users. This ensures that the stated needs remain in the front and centre of the enquiry.

The aim of this Handbook is to provide decision-makers with the necessary information and tools in order to help them make decisions that respond to their needs, within the constrained environment in which they are in, especially with respect to budgetary and technical limitations. It is within the objective of this Handbook to describe the relationships between each of the components of a statistical programme on CoP and to stress the importance of adopting coherent and integrated strategies from the definition of needs to the determination of the required outputs and data collection approaches and dissemination strategies. This is the focus of the following sections.

4.2.2 Surveys

Surveys are the most common data collection vehicle used by countries with existing CoP programmes (FAO 2012). The main reason for this is that most of the information on CoP is better known by the farmers 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 programmes. Comprehensive recommendations for survey design and methodology are 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 programme. This section provides some background issues on survey strategies used in agricultural surveys. The description of the most standard sample designs is given in Annex 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 multipurpose surveys. Single purpose or stand-alone surveys are surveys entirely designed to address one major purpose. Examples abound of stand-alone surveys in agriculture, such as production surveys or producer price surveys. Conversely, multipurpose or omnibus surveys are designed to collect data on different (but generally related) topics using a unique data collection vehicle. Examples of omnibus surveys in agriculture are those that collect at the same time data on production, revenues and inputs. Multipurpose surveys can be part of an integrated survey strategy as they contribute, by using a single survey vehicle, to ensuring ex-ante the integration between different variables. The Global Strategy research activity on the integrated survey framework provides a more ample description on the different methods used to foster survey and data integration (FAO, 2014)..

As with any data collection programme, understanding the issues within the country context helps the programme designer make the most informed decision. A survey of country practices (FAO, 2012) revealed many examples of successful programmes that 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 include the purpose of the survey, costs, statistical infrastructure, sector maturity and respondent literacy. The decision on whether to use a single or multipurpose survey should also be based on the country's overall approach to align itself with the integrated survey approach promoted by the United Nations Statistics Commission (UNSC) and the statistical guidelines developed by the Global Strategy to Improve Agriculture and Rural Statistics.

Factors that favour a stand-alone survey:

Like all single purpose statistical surveys, a stand-alone survey designed to estimate CoP for an agricultural product can be purpose 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 the available sample size to that target population, thereby reducing sampling complexity and increasing precision and accuracy (or, for a given level of precision, reducing survey 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 recordkeeping practices are weak or problematic, then it is widely accepted that data collection has to take 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 allows for focused training and teaching of the data collection staff to conduct a survey consisting of complex concepts. This would also give the agency time and experience to understand how best to integrate the CoP programme into their ongoing statistical programme.

Factors that favour an omnibus survey:

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 are normally collected as well. Several countries have adopted this approach for these reasons;

- In addition to the collection load, integrated surveys 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 reused, 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 data analysis because, by their nature, the analysis is *de facto* linked to other data collected on the survey. This ranges from other agricultural products, to off-farm and on-farm family income, to social variables, such as owner education.

- The total response burden is reduced for respondents that 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 edit fields, allowing 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: for example, the same classifications, concepts and variables are used. Integrating different stand-alone surveys requires a high level of coordination between the different units in charge of the surveys. This process is more prone to errors and omissions.

BOX 4.1
Omnibus and stand-alone surveys on cost of production: country examples
Countries relying on a stand-alone survey for the estimation of cost of production
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 programme and the formulation of development plans and programmes.
In **India**, since the 1970s, 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.

Countries relying on omnibus surveys for the estimation of cost of production
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).
In **Australia**, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has collected CoP data through farm surveys for 33 years.
Cost of production estimates in **Zambia** are drawn from two integrated surveys: the Crop Forecasting Survey (CFS) and the Post-Harvest Survey (PHS). These surveys have been jointly conducted by the Ministry of Agriculture and Cooperatives (MACO-Agriculture Statistics and Early Warning Section) and the Central Statistical Office (CSO) since the 1990s. 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.

Source: Authors, based on a review of country practices (FAO, 2012).

BOX 4.2
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 has been 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 planned to 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 ICoP are drawn from the Crop Cutting Survey. Three sampling frames were used in the Crop Cutting Survey: (a) a list of census blocks drawn from the agricultural census; (b) a list of households with farmers' addresses, updated two weeks before conducting the survey; and (c) the list of parcels to be harvested in each sub-round.
There are three 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 two 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 wetland paddy).

Source: Ronzon *et al.* 2014

Towards an integrated survey strategy

The Statistics Division of the United Nations (UNSD) has been actively preparing guidelines and recommendations for the implementation of economic surveys. Based on best practices observed from national statistical offices (NSOs), the United Nations Statistical Commission (UNSC) has adopted the Guidelines on Integrated Statistics. In essence, the guidelines recommend a holistic approach to survey taking. In particular, the guidelines suggest that countries design economic surveys that can explicitly be used in the preparation of their national accounts (UN, 2013). 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 the 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.

Particularly of note is the suggestion that agriculture surveys be folded within this integrated survey system approach, which is a key component within the Global Strategy.

The following are 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 sampling frames as the basis for integration;
- Create a register of agricultural and rural households using population censuses and ensure that 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 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 the set of 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;
- After the core statistical system has been defined, define the basic data collections for household and enterprise surveys;
- Disseminate official statistics in a timely manner, making them readily available to all data users, including microdata (respecting country confidentiality requirements).

There are many benefits to using an integrated survey framework. The Global Strategy research activity on the integrated survey framework has identified four main positive externalities to this approach:
- It adds value to the entire statistical data collection and management system;
- It reduces the costs of statistical collection and the burden placed on respondents;
- It increases the consistency and accuracy of statistical outputs;
- It promotes greater exploitation of common technologies, analytical methods, tools and processes.

In addition to conducting integrated surveys, information on costs of production could be drawn and compiled from agricultural censuses and associated surveys. This modular strategy for agricultural censuses and surveys is supported by the 2010 round of the World Census of Agriculture (WCA, FAO, 2010). According to those guidelines, census activities should comprise two main components:
- A complete enumeration of a very small number of structural items (only 16), which can be used to construct appropriate sample frames.

- One or more supplementary modules, conducted on a sample basis, to provide more detailed results for additional data. Surveys on cost of production could be one of these supplementary modules and, together with other potential data sources, could improve the economic characterization of the farm.

Sample frames

A well-designed sample survey can be completed rapidly. Sampling designs make it possible to make inferences and provide precision measurements. A well-designed sample for national estimates requires a surprisingly small number of farms. This is conditioned, however, to the selection of appropriate samples for agricultural statistics, which start from accurate, complete and up-to-date sample frames.

A sample frame is a set of units defining the universe of the population of interest, including, among others, the universe of businesses, of households and of farms. For agricultural statistics, a basic sample frame is a listing of the units to be selected at any stage of the sampling process: listing of farms (list frames) or listing of parcels or of any land unit (area frame) covering the targeted territory, such as country or region.

Different frames can be combined to form what is known to be a master sampling frame, from which samples for different purposes can be selected. For example, a listing of households can be combined with a list of farm holdings and with a list of geo-referenced parcels, with established rules linking the household to the farm and the farm to the parcels.[8]

The construction of frames for agricultural statistics relies on information that may be gathered from censuses (population or agricultural censuses), administrative records, including, among others: tax receipts, aerial or satellite imagery and the regular undertaking of surveys and censuses. These sources of information permit to construct and update the frames needed to compute nationally representative estimates for a range of agricultural statistics.

Some of the most important characteristics of list frames, taken from the draft *Handbook on Master Sampling Frame for Agriculture* (FAO, 2015), are provided below:
- The lists must be continuously updated;
- Care should be taken to avoid selecting twice the same unit; the risk of duplicates is higher when using multiple frames if linking rules are not appropriately specified;
- The use of auxiliary data in list frames provide for efficient sampling of large commercial farms;
- With list frames, cost efficiencies can be obtained from collecting data by mail or phone instead of through personal enumeration in the case of area frames;
- It may be easier to locate the farm operator in list frames but it may not be possible to observe the land.

Regarding area frames:
- They should be complete in that they cover all of the targeted area;
- Association rules with reporting units, such as households and farms, should be established;
- The physical location of the point or segment sampled should be known and identified so that it can be linked to land-use;
- The sample is generally not efficient for rare items. For example while it ensures that large units, such as commercial farms, are selected in the sample, it might be more efficient to select such units from a list frame;
- Area sampling may result in selecting shares of parcels ("closed" approach), which may increase the complexity of data reporting and estimation; alternatively, the "open" approach, which entails selecting and collecting data for all parcels falling into the selected segments can be used, but it is statistically less efficient;
- Area frames remain up-to-date even if land-use changes slowly and because the coverage is complete, under-coverage disappears and only sampling variability will be affected.

---

8 For a more comprehensive discussion on the construction and use of frames and master sampling frames in agriculture, refer to the Global Strategy website: http://gsars.org/en/handbook-on-master-sampling-frames-for-agricultural-statistics/.

4.2.3 Typical farm approaches

The use of sample surveys to collect data on agricultural CoP is only one of a number of data collection vehicles at the disposal of countries. Several national organizations or regional and global networks have adopted a strategy that consists of 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, the first term is preferred to avoid any confusion between the "representative" farm and the statistical representativeness of the data, which is generally not ensured by this approach.

As these data collection methods are widely used, it is important to present and discuss them in this Handbook, especially with respect to its complementarities with sample surveys. In Brazil, the Companhia Nacional de Abastecimento (Conab) uses this approach to construct regional and national figures on CoP for the major commodities. The data refer 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 is determined. The role of Conab is to coordinate the work of the panel, consolidate the results and ensure their consistency across time, space (regions) and commodities (Conab, 2010). The agri benchmark network[9], at the 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 described below. Although there may be some variations depending on the countries, commodities and end-uses of the data, most of these steps are common across the countries and organizations that use this approach. The subsequent description is appropriate for analysing international competitiveness of main regions or production systems for a particular commodity. It should be noted that for other purposes, it is possible to define other typical farms in other regions.[10] As far as possible, available statistics are used to (a) identify the relevant regions and (b) to identify the relevant farm characteristics, such as farm size, production programme, and combination of enterprises or ownership in land.

Selection of regions and locations: For a given commodity, the regions 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 and the end-uses of the data (regional and/ or national level information) and on the budget allocated to the programme

Determination of the typical farm: One or more typical farms are determined in each of the regions selected for the programme. The typical farm can be defined in many ways, but it is generally constructed to represent the most common characteristics of the farms in the region, namely the modal farm. Some of the characteristics used in the construction of the typical farm are the following:

- Type of production (conventional or organic);
- Technology used, such as use of chemical inputs, labour and rate of mechanization;
- Combination of enterprises, namely specialized crop farms or mixed farms;
- Farm size, such as in ha or output value;
- 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);
- Any other dimension that reflect local production patterns.

---

9   Agri benchmark is a global non-profit network of agricultural economists, advisors, producers and specialists in key sectors of agricultural and horticultural value chains. For more details see www.agribenchmark.org/agri%20benchmark/who-we-are.html

10 For example if analysts are interested in the economic well-being of smallholders, typical farms will not be established in the region with the highest share in the total output of a particular crop, but instead in regions in which smallholders are most important.

In a second step advisers from the selected region are to be 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 (non-organic) then 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.

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 minimum level of representativeness of the derived statistics. This is, of course, at the price of increased programme costs.

Determination of the panel of experts: The determination of the modal or typical farm and of its economic characteristics, among which CoP, is chosen by a panel of experts with a wide range of experience in the food and agriculture sector.

The composition of the panels may vary, but they generally include:
- Selected number of farmers;
- Representatives from cooperatives and farm associations;
- Extension service workers and employees from other technical assistance bodies;
- Government and non-government employees and employees from organizations related to agriculture;
- Producers of agricultural inputs, machines and equipment;
- Researchers from 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 they are not required to disclose any individual information which might be deemed confidential 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 consensus estimates. The organization in charge of the programme is generally tasked with coordinating and facilitating the discussions and engaging the experts to obtain the required information, such as data, publications and events, 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 is used as the starting point for the discussions. These parameters are then combined by the organization in charge of the programme with data on prices and output levels to construct CoP statistics. The outcome of the cost computations is 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 may be needed until a consensus on the final results is reached.

The advantages and disadvantages of typical farm approaches, well known, are succinctly described as follows.

Advantages: The outcome of this approach is a complete and consistent data set of all major technical and economic parameters of a farm, which allows a reliable estimation of CoP for the defined typical farms. As all major technical parameters are documented, it is possible to run all kinds of analysis related to environmental issues, such as greenhouse gas emissions and nutrient balances analyses. 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 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 the results are comparable, as 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 such as the one used in Brazil, a much higher level of spatial 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, except in the specific cases in which 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, which, in turn, would result in an increase in the data collection costs, which is 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. The resulting data are often used to assist with farmers' planning and are used to help create farm budgets.

Typical farm approaches can also complement or serve to prepare 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 serve as 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 that institutions involved in typical farm data generation highlight 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 in which 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, with the exception of 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, some of the above-mentioned shortcomings could be overcome.

4.2.4 Choosing among the data collection approaches

As discussed extensively in the previous sections, it is clear that each approach has its advantages and disadvantages. For example, it is important to realize that many of the advantages of a statistically sound survey approach will be eroded if there are gaps in the process and statistical infrastructure upon which it is reliant. Failure to use a comprehensive and reliable survey frame, weak techniques to counter known survey errors (sampling and non-sampling) and poorly trained or insufficient data collection staff all could reduce the advantage that a statistically sound sample might provide. On the other hand, typical farm approaches do not take into account the full array of variability in farming structures. The resulting statistics, which lack statistical representativeness, cannot generally be used for policy-making at regional or national level.

It is, however, possible to combine the respective benefits of both approaches, namely statistical soundness and cost control and precision, in the data collection. A hybrid strategy combining the elements from using sound statistical sampling with the economy of a typical farm approach could be characterized by:

*   Undertaking, at regular intervals, structural surveys in order to assess with precision and with sufficient statistical soundness the production costs of given commodities. The periodicity of these surveys should be adapted to the pace of change of the production technologies;
*   Statistically sound techniques, such as cluster analysis, can be used to construct homogenous groups of farms (farm types) on the basis of the data produced by the structural surveys;
*   A reduced number of farms can be selected from these homogenous groups on the basis of which data on cost of production will be established, updated and cross-checked with the data compiled from the structural surveys.

The structural survey and the use of factor analysis to construct farm typologies ensure a certain degree of statistical soundness and representativeness of this approach. The reduced number of farms that are surveyed within each group allows for a detailed economic characterization of the farm and at the same time contributes to limiting the overall cost of the data collection.

Other examples of hybrid strategies include using CoP estimates derived from surveys as a historical benchmark and the use of current indicators to bring the benchmark estimates to the current time reference period. This approach is used in the United States and in the Philippines.

4.2.5 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, such as tax records, cadastral records, administered prices, and market data on inputs, such as market prices of fertilizers, regional wages and interest rates. These sources are generally used in combination with survey data when information is missing, such as data missing on values but available on volumes, to impute costs of inputs owned or produced by the farm, such as manure and unpaid family labour, to estimate opportunity costs, and to project CoP estimates between two survey years. For example, the United States Department of Agriculture uses projections based on production and prices data, assuming fixed technical coefficients, to estimate CoP for non-survey years.

Adequate use of these alternative sources of information can also help lower the cost of the data collection process, as explained earlier. Some of the main alternative data sources are 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, from which 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 or regulated wages for agricultural activities);
- Input prices which, combined with survey-based information, can be used to compile cost estimates.

Although there is a cost to produce and maintain this data, they are generally obtained from well and long-established programmes 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. This opportunity should be leveraged to the maximum. Data limitations, such as lack of timeliness or issues related to confidentiality, may limit the usability of the data.

Data from public or private organizations:

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

- Specialized public and private financial institutions that can provide information on credits allocated to agriculture;
- Research organizations with experience in analysing agricultural production;
- Farmers' unions;
- Industry organizations, such as input and machinery suppliers;
- Farm extension services.

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

4.3 ADDITIONAL DESIGN CONSIDERATIONS

Itemized below are several additional considerations that a statistician must take into account when estimating cost of production. The choices made will affect the cost, reliability and usefulness of the resulting estimates.

4.3.1 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 are compiled and their comparability with indicators compiled from other data sets. It also directly affects the ability to link and integrate these data to other data sets.

The unit is also important from a data accuracy perspective: more reliable data are obtained if questions correspond to the interviewee's ability to report, namely if they better match farm practices and farm recordkeeping. To the extent that farm recordkeeping 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 recordkeeping practices in any case.

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

Farm (or holding) level:
A precise definition of the agricultural holding adopted by the WCP2010 is provided in the glossary. This is probably the level that is the closest to the recordkeeping practices of the farm and to the interviewee's ability to report, especially on costs related to inputs that are jointly used to carry out different activities of the farm, and therefore difficult to separate. Data at the farm level are 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 are also needed at the commodity or activity level to measure the relative profitability of different commodities. If this is the case, farm-level estimates need 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 are necessary to compile crop-level estimates of farm profitability, which are needed to evaluate the relative competitiveness of the different commodities within the country and the same commodities produced abroad. Collecting cost data at this level can be challenging because many cost items, especially fixed costs, are used jointly by 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 for production processes of each commodity of the farm. Furthermore, even for inputs that are separable in theory, purchases are often recorded by the farmer at the level of the economic unit (farm) and not for the activity or crop. Costs can be allocated using technical factors, such as application rates for fertilizers and pesticides, at the risk of reducing accuracy and introducing bias into the results.

Plot level:
Data on costs and returns for crops are often collected for a specific plot. At this level, it is easier to relate the data collected on input use to the actual production of a specific plot and, therefore, ensure that the estimates reported make sense from an agronomic and economic point of view (kilograms of fertilizers per hectare of cultivated land and labour used per plot, for example). However, as with crop-level data collection, the question remains on how to allocate non-separable inputs to the specific plot (or crop) for which data are gathered. To collect data for individual plots in a statistically sound way, a method to identify each plot is needed so that the target plots can be selected. A precise and up-to-date registry of landowners is also useful to connect the plot identified with the appropriate owner or manager to which the interview may be addressed. These two conditions are difficult to achieve, especially in developing countries. However, even without a proper and up-to-date registry of landowners plots can be selected

through area frames and matched to the farm that cultivates it. This is the procedure adopted in many developing countries, especially by those in Latin America (Ecuador, for example).

Household level:

The household can also be the unit from which information on costs and returns are 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 farming is relatively widespread and farm revenues represent a significant share of household income. Collecting data at the household level allows for the compilation of indicators that measure food security of households and other variables associated with family composition, such as its size and location, and other variables of the household that may be of interest for food security analysis. If the household is the unit of observation chosen, the list frames, samples and data used and produced within national household surveys could be leveraged to the benefit of the CoP programme. This will certainly alleviate pressure on the budget of the programme and improve the quality of the data by enhancing its consistency with other variables and facilitating cross-checking and validation, such as declared household income and farm revenues. One drawback of relying exclusively on this data collection method is the lack of exhaustiveness of the information on costs, as 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 objectives of the programme, 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 recordkeeping practices in the sector. In most developing countries, recordkeeping 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 4.3

The choice of unit of observation: some country examples

Farm holding

The **FADN** (European Union) collects the 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 the farm level, the monetary value of crop inputs, livestock inputs and other farm costs, such as overheads, depreciation, hired labour costs and interest costs. The information is not available per unit of commodity, such as per ton of wheat, corn or rapeseed.

Farm holding and estimation of commodity CoP

The **ARMS** (United States) collects commodity-specific costs, such as direct cost, input quantities and production practices by commodity, including, among others, seeds, fertilizers and chemicals. Non-specific costs, such as overheads are collected for the whole farm and then 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-specialized, 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 are collected on all crops grown on all plots farmed, and further allocated to each single crop (Sen & Bhatia 2004). The farm level data pertaining to crops 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 for a group of plots, in the case of sugarcane planters, as they tended not to keep separate accounts for each plot. Total costs could then be calculated per hectare and per kilogram of product.

Household and plot

CFS (**Zambia**) does not include CoP calculation as it is primarily aimed at forecasting the future crop production of the current cropping season. However, enough household and field-level data on input use and production is compiled 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 CFS, which may explain why indirect costs were not calculated by Burke *et al*. (2011).

Source: Ronzon *et al*. (2014).

4.3.2 Data collection mode

In addition to the complexities that are endemic to all surveys, CoP surveys are quite complex with regards to the subject matter. Determining the unit of observation (enterprise or commodity) and accounting for the costs, cash and non-cash, actual and imputed, makes this a difficult survey to conduct from a data collection perspective. Dealing with survey respondents that do not have the capacity nor complete records adds to the task.

As each country's circumstance is different, there is not a perfect solution to this challenge. What is widely agreed is that data collection should be tailored as best as possible to the survey respondent. It follows that in countries where detailed farm recordkeeping is common and sophisticated, an approach that leans more heavily on self-enumeration can be implemented, thus reducing the cost. When the target population is less educated and perhaps even illiterate, an approach that relies on skilled interviewers becomes necessary. Of course, there are many paths that combine approaches with equally valid results. For example, some countries provide diaries or legers only to a selected pool of respondents. This is the case, for example, of the Philippines in the context of the ongoing Farm Record Keeping Project (FRKP), which has recently been implemented by the Bureau of Agricultural Statistics to enhance the capacity of farmers to generate better quality farm-level data. This approach can help reduce problems associated with recall bias, but it has a different set of issues to be overcome.

Questions should be asked in a manner that most closely resembles the recordkeeping practices of the respondent. This holds true for all countries. By extension, adopting this approach means that the statistical organization asking the questions in this way will have additional work associated with compiling the data into the exact form that is required. Still, it is generally accepted by statisticians that this approach is best done by the statistical organization and not the respondent. An example of a questionnaire, developed by a group of experts, enumerators and farmers as part of the field test of the Handbook carried out in Tunisia, is provided in Annex 1.

Whichever method is chosen, interviewer training is an important aspect of the survey process. Support must be extended to respondents who self-enumerate and to interviewers when out in the field collecting data, through the provision of adequate manuals.

4.3.3 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 such factors 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 that is produced in a well-identified and circumscribed area than for a production more uniformly distributed across the country or area of interest);
- The budget to be allocated to the programme.

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.[11] Using standard industry definitions and classifications leverages the uses of ensuing data collections, and allows estimates to be used in the compilation of internationally comparable agriculture sector accounts.

---

11 The ISIC detailed structure is available at: http://unstats.un.org/unsd/cr/registry/isic-4.asp.

4.3.4 Geographical scope

The geographical scope to be adopted essentially depends on the intended uses and users of the indicators. If data are intended to be used for the compilation of national accounts for agriculture, it is essential to ensure that the data collected are representative for the country as a whole. CoP data are often required at subnational level given the influence of agro-climatic conditions on farming practices and the need to produce data that can be used to assess regional commodity specialization and relative profitability. An appropriate stratification scheme ensuring regional representation and allowing an upscaling of the results at the national level is often a prerequisite 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 that the data collection efforts be focused on those areas. Data for the residual areas can be either estimated or collected using less comprehensive and less expensive means.

4.3.5 Frequency and timing

For all statistical programmes, the frequency of data collection must be determined. There is no general prescription for this decision; it is a judgemental question best decided through a dialogue between the statistician and the ultimate data user, within the limits imposed by the financial envelope devoted to the programme.

The frequency of CoP surveys depends on several considerations, which include the following:
- Policy use and priority relative to other statistical programmes, 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 affect CoP estimates and the frequency with which these factors change, such as adoption of new agricultural technologies, changes in environment/climactic conditions and growth in industrial demand for crops, such as in biofuels;
- National or international statistical obligations that require a specific survey frequency;
- The budget.

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

The decision regarding 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 conduct 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. In locations where statistical infrastructure is fixed, a trade-off between a CoP programme and other statistical programmes is required.

Country experts generally acknowledge that not conducting an annual survey is less than ideal, but they 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 frequency less than annual, there remains a requirement that base-level data, such as area harvested, be collected on an annual basis with which to update the previous CoP survey data. Furthermore, 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 result of 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 the memory bias and increases data quality.

4.3.6 Data Collection errors

When collecting data, all methods are subject to some error and when collecting data using surveys (of which a census is a specialized case), the errors are known sampling errors and non-sampling errors.

Sampling errors affect the degree to which the selected sample differs from the population of interest. It 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 reflect 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 percent 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 percent that the true estimate lays outside the confidence interval. Sampling errors can be reduced by increasing sample size, with the extreme case of conducting a census that reduces the sampling errors to zero: as data from all units of the population are collected for a census, 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 and 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 Annex 3.

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 estimate will be biased systematically upwards or downwards. Some of the more common sources of non-sampling errors are noted below:

- *Coverage errors:* These errors 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 subpopulation 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 inappropriate questionnaire design, use of terms which are not understood, lack of recall of the respondent, ill-timing of the survey instrument, insufficient interviewer training, misalignment of concepts with questions and language barriers. These errors affect the accuracy of the resulting estimates as the value obtained from the 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 farmers in small, medium and sometimes large holding tend not to keep records 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, such as higher non-

response rate among small farmers, biased estimates could result. If a certain segment of the population does not respond to the survey, then this segment of the population will be underrepresented in the survey population, which will create a potential source of bias. Survey non-response can be limited by the adoption of an appropriate data collection approach: a shorter and simpler questionnaire generally reduces the rate of partial and total non-response. Follow-ups with interviewees (by phone or in-person) also help to reduce 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*: These errors 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, such as unit mistake, that can be detected by the use of data validation and checking rules.

4.4 COSTS OF DATA COLLECTION

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 programme, there is always a trade-off between the completeness and accuracy of the data and the budget that is allocated to the programme. The final decision on the amount to be spent on a statistical programme, be it a survey or any other data collection mechanism, is ultimately a political one.

4.4.1 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 and a range of other costs, which vary with the number of interviewees. This is typically the case for censuses or sample surveys, where interviewees are located in different areas and personal face-to-face interviews are being carried out. Censuses and sample surveys therefore require a relatively high budget to be implemented. However, these data collection mechanisms are also the ones that can potentially provide more accurate and meaningful results, 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 out by member States for a maximum of 160 euros (USD 175) 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 European Union go well beyond what would be requested for a complete CoP survey.

4.4.2 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 they do not generally ensure the representativeness of the results, which, therefore, cannot be extrapolated at the regional or national levels.

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 representativeness in the results. This approach would entail 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 (every 5 or 10 years).

4.4.3   Administrative sources

Although there is a cost to produce and maintain the data, these are generally well and long-established programmes that 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, making it a good opportunity to leverage to the maximum. Data limitations, such as lack of timeliness as with land registries, or issues related to confidentiality, might limit the usability of the data.

4.4.4   Approaches to reduce 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 programme 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 programme if the objective is to assess the profitability of smallholders or if data can be obtained for those 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 programme is to assess the profitability of commercial exporting farms compared to competitors in neighbouring 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 that are expected to be the most discriminant for CoP, such as activity type, farm size and agro-ecological area, 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 a minimal cost provided, of course, that 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 or an 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 costliest interview mode, as enumerators have to be compensated for their time and for their transport costs. When the risk on response rates 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 programme. Large farm operations, for example, that 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 programme. For example, if minimum prices offered by the government need to be adjusted every year, an annual CoP programme or an acceptable updating strategy is necessary. In this case, again subject to the user demand for precision, full surveys of data collection programmes need not be conducted. Production functions in agriculture are typically stable from one year to the next, in normal conditions. It is often considered acceptable 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 programmes are conducted for more than one commodity, then this means that surveys might be carried out each year on a rotating basis for the commodities included in the programme. For example, wheat in year 1, potatoes in year 2, rice in year 2, wheat in year 4 and so on. This is the approach adopted by the United States Department of Agriculture, among others. This allows the survey costs to be distributed more evenly across the years.

Using complementary data sources:

Food quality information accessible from sources other than from farm surveys can be used either as primary information to improve or derive a final estimate or to cross-check data collected from other sources. The information may come from an administrative or private source. Examples are using data on regulated wages to estimate labour costs, using regulated rental prices for agricultural land to impute land rental costs and using data and technical parameters coming from technical studies or farm extension services to proof check data collected within surveys. The use of complementary information reduces the burden on respondents as questionnaires 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.

5

Guidelines for data collection and estimation

5.1 INTRODUCTION

This section provides concrete and applicable guidelines for collecting and estimating CoP data. When thinking of costs, it is often useful to consider and categorize inputs. In this manual, direct expendable inputs, non-specific or overhead inputs, labour inputs, capital inputs, land and pre-production (establishment) costs are considered. Costs, in turn, can be broken down in many different ways which can overlap with each other. Cash costs are separable from non-cash costs; direct (or specific) costs are separate from indirect (or non-specific) costs; variable costs are different from fixed costs, but all of them can include the same agricultural input. Feed costs can be considered as cash costs if they are purchased from a feed supplier. Alternatively, they can be classified as non-cash costs if the feed is farmer-grown and supplied. The breakdown used in this Handbook distinguishes variable costs from fixed costs, as well as those costs that can be directly attributed to the commodity under study from non-specific costs. Issues related to imputation for owned inputs or the determination of opportunity costs are addressed within each cost item. Given their specificity, pre-production (establishment) costs and their treatment is addressed separately.

In the guidelines for estimation, a distinction is made between the ideal or "first best" or recommended approach and other approaches, which may 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.

5.2 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, and not just out of pocket (cash) expenses. This becomes significant for some items, including, for example, owned farm inputs, such as labour and farm produced feed/seed 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. Inputs that are purchased and used during the production period include expenses, such as seed, fertilizer, and pesticides, as well as hired capital, such as rented machinery or bullock

livestock. Costs also include the 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 market are sometimes included with the decision to include them dependent on where and how the transaction and ownership of the commodity takes place. If the farmer receives a price at a specific location and must deliver his product to that location, then the cost of transporting the goods should be included and reported in a separate item.

Cost items for inputs that contribute to production over several production periods, such as machinery and buildings (capital service costs), must also be measured. Finally, the opportunity cost of owned capital, including the time value of the money 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. This last component of cost makes up the main difference between economic costs and business or accounting costs.

Expenses that are related to the management of the farm are unique in nature. Their contribution to farm production is different than the contribution given by 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 make production more effective: which inputs to use, in which quantities, namely 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 percent, according to Sen & Bhatia (2004). It is therefore necessary to keep track of these expenses and compute estimates of CoP with and without management expenses, as is done in the case of the Indian Cost of Cultivation programme, for example.

It is not the purpose of this Handbook to delve into all of the details associated with the data collection for all agricultural production and associated revenues. However, given their close complementarity with CoP information in measuring farm economic performance, a few general guidelines are provided here.

Revenue

Measuring revenues consists of adding together returns from the sale of agricultural products, government programme receipts and other miscellaneous revenues. In principle, measuring revenues from the sale of farm products is straightforward: it is equal to the unit price received from the sale of the product multiplied by the quantity sold. Government programme receipts are programme or support payments that relate to the sale or production of those same products. Special care is necessary regarding the link between government payments to a certain commodity or activity. In cases in which such payments depend on the production or 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 constitute a lottery gain rather than reflecting the economic performance of a particular production system. Miscellaneous receipts (those receipts related to the sale of the agriculture product under investigation), such as the sale of cull 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. It is common in CoP estimation to value crops at the time of harvest as the marketable production multiplied by the current market price as this eliminates the necessity of valuing inventory and associated holding costs.

Valuation

The prevailing market price is the best one to use to value economic costs and returns. When 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, namely 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 is 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 the 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 in Morocco are seldom used (in the 1991 CoP survey they represented only 10 percent of the sample), thereby limiting the relevance of using average rental rates to impute the costs associated with owned agricultural land.

To the extent that markets of a sufficient size exist, local market prices should be preferred over regional or national averages. If the markets are too thin, market prices in neighbouring or similar regions may be used.

Subsidies

Inputs that are subsidized often present a challenge for statisticians when estimating CoP. The correct treatment of subsidies depends on the final use of the data. For the producer, the correct valuation for the input subsidized corresponds to the price actually paid by the producer for such goods; in other words, the price that is paid after the subsidy is applied. However, simply using net or subsidized prices understates the economic CoP and hampers the ability to compare costs across regions or sectors that do and/or do not have subsidized inputs. For that reason, statisticians should collect both a market price for the input and the net (after subsidy) price for inputs. Analytical indicators should document and indicate how subsidies were treated.

Timing, inflation adjustment and time discounting

Differences in the timing of production, cash expenses and selling of products result in inconsistencies between different indicators. As a result, care needs to be taken from a data collection perspective, namely the questionnaire design and interview process, as well as from an estimation point of view (inflation adjustment and time discounting). In a case in which 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. The stock that 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 and for facilitating international comparisons, selecting a calendar year is a convenient and, in most cases, a reasonable option. This is because 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. To ensure comparability in time, revenues and costs should be brought to a common point in time using an inflation rate and, if possible, a time-discounting factor (which can be approximated by long-term interest rates). The reference period can be the last month of the growing year or mid-point of the calendar year.

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 must also be collected for the same land area. It is best if this unit is equal to the customary or typical selling unit, such as per kg of meat, litres of milk or dozens of eggs. This is because users and suppliers of the data can more easily relate to the unit of sale. In the case of crops, using a planted area basis enables 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 programme payments.

5.3 ALLOCATING JOINT COSTS TO SPECIFIC ACTIVITIES

5.3.1 Importance and scope

To fully estimate 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 that are solely related to the product in question, doing 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 need to be allocated across the commodities. Joint inputs can be of many forms but are usually presented in three forms:

- Inputs that are used in a process that produces more than one product. An example of this is feed used for animals that yield both milk and meat. In that case, these are joint products as the production technology of one commodity (meat) cannot be separated from the other one (milk);
- Inputs that can be used for more than one product even if the production is not technically related to the other. For example, farm equipment that is used in the production of more than one product;
- General farm management and overhead expenses, such as office space and trade association fees.

Allocating joint production costs to specific activities or more commonly to a specific product is, therefore, a necessary step for determining the cost of production. The difficulty becomes less acute as the degree of specialization of the farm increases. It is also reduced as farm recordkeeping practices improves. While there are many approaches for doing this, none are perfect and all of them can result in biased or faulty estimates.

Some inputs to be allocated are specific to livestock production, including, among others, feed, certain machinery and equipment, such as milking equipment, while others are specific to the cultivation of crops, such as fertilizers or crop-specific machinery, such as harvesters. Other inputs may be common to both livestock and crops, such as fuel and energy expenses, general overhead, such as management work and taxes, as illustrated in Figure 5.1.

FIGURE 5.1
Inputs to be allocated for crops, livestock and mixed activities

LIVESTOCK

Feed

Buildings

Machinery

Farm equipment

Labour

Farm management

Taxes, licence fees

Insurance premiums

Electricity and heating

Fuel and lubricants

Water

CROPS

Fertilizers

Plant protection

Buildings

Machinery

Farm equipment

Labour
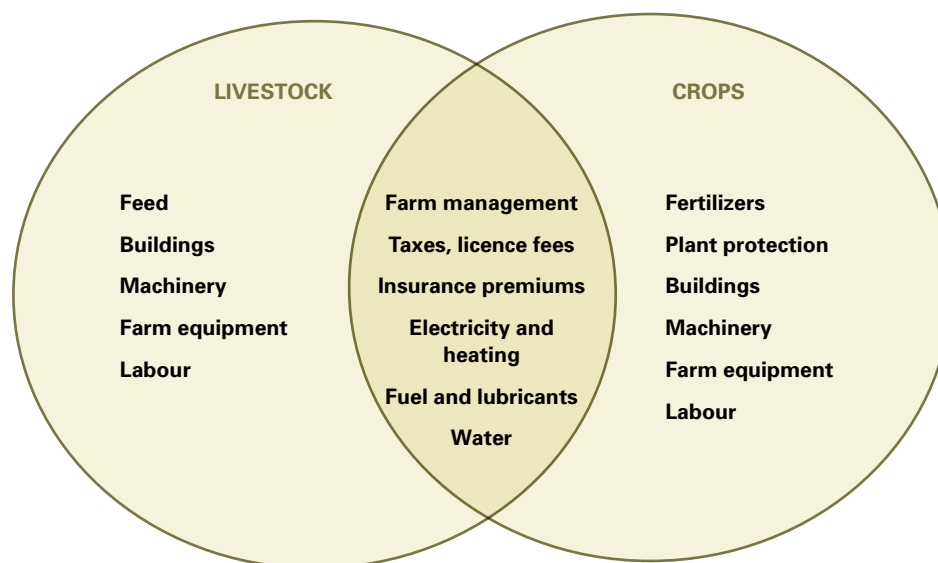
Source: Authors, 2014.

The very nature of this cost category implies that there is no "true" or "false" way to do this allocation. Beyond directly asking the farmer himself to perform the allocation, there are approaches that approximate the underlying true value, such as the "per unit approach" in the case of crops or more sophisticated ones, such as the "machine run time approach" which, for example, is applied in the agri benchmark crop branch to allocate machinery-related costs. In all cases, the first requirement is to (a) establish a uniform algorithm and (b) make transparent the one that has been used. Ultimately, the choice of the allocator used is dependent on the expense item being allocated and the availability of data to the statistician. The choice of the allocator also determines which additional information is required to carry out the allocation, some of which may come directly from the survey and the rest from auxiliary sources.

To the extent possible, each cost item should be examined independently and an allocation formula should be developed for that item. As there are many possible approaches and none are perfect, it is paramount that the statistician explain what has been done and the underlying assumptions that were used so that the end user can fully understand the data set presented and make allowances or adjustments as required to the data set as he sees fit. The most common allocation techniques are described below.

5.3.2   Allocation methods

Respondent-based allocation:
This consists of directly asking the farmer or farm manager to estimate the share of the costs associated to the different activities of the holding. The self-allocation procedure is only applicable to cost items that are the easiest to allocate, such as some variable inputs (fuel expenses, for example), or aggregate cost items, including general management costs. This approach should be used only if farm recordkeeping practices are sufficiently developed in order to limit the potential biases in the responses. Several countries have adopted this approach. The United States National Agricultural Statistics Service (NASS), for example, asks the respondents to the Agriculture Resource Management Survey to allocate the share of the different expenses, including operating and capital expenditures, to the enterprise or commodity of interest of the survey. A good example of this is the 2013 Rice Questionnaire Part III in which the only item that remained unallocated at the data collection level was farm management expenses. Other countries, such as the Philippines, ask farmers to allocate joint costs to the respective commodities. According to

the findings of the Case Study in the Philippines (box 5.1), this allocation procedure does not pose major problems for the respondents, to the enumerators or to the statisticians that analyse the survey results. The Philippines also introduced in 2014 a project aimed at improving farm recordkeeping practices. It is hoped that the project will help improve the medium to long-term quality of the statistics on commodity-specific costs of production for which the level of precision of the allocation process is essential.

BOX 5.1

Allocation of joint costs in the Philippines: an example

A sampled palay (paddy rice) farmer stated that he used a hand tractor on his farm. The next questions should be:

• How many units were used?

• When were they acquired or constructed?

• What were the costs involved?

• Were there any repairs or improvements to the units and if yes, what was the cost?

• What is the expected useful life of the unit?

• What was the percentage of use on the specified (focus) palay farm parcel?

The sampled farmer has three parcels of farm distributed as follows:

Parcel 1- palay - 2.00 hectares----focus parcel

Parcel 2- palay - 1.00 hectare

Parcel 3- mango - 0.50 hectare

These data items are obtained from the survey questionnaire.

The question that needs to be settled is whether the farmer used the tractor on all three farm parcels. If yes, the farmer is asked to allocate the use according to the area of each parcel of land. In this example, the total farm area is 3.50 hectares, the focus parcel has (parcel 1) 2.00 hectares or 57 percent and this percent amount would be allocated against the focus parcel costs. If the farmer indicates that he only uses the tractor on palay fields, then 67 percent (2/3 hectares) of the tractor costs would be allocated to the cost of producing palay on parcel 1.

Source: Authors based on discussion with country experts, 2014.

Allocation keys:

When determining an allocation formula, reported data should be used as much as possible so that bias can be minimized for at least lower levels of disaggregation (the whole farm as distinct from the farm enterprise). 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, a reasonable allocation key would be to use the time that the tractor was used for each commodity or the distance (number of field passes) made for each commodity to allocate the joint fuel cost. If this information is not available, the proportion of land cultivated for each crop may be used. This approach ensures that the aggregate fuel expense is in agreement with what was reported. Similarly, fertilizer expenses may be recorded as one item for the farm and not reported for each commodity. In this case, a simple allocation rule based on the relative share of land occupied by each commodity may be used. Care needs to be taken to ensure that the proportions of tractor use, fertilizer applications and land cultivated sum to 100 percent 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.

As these approaches are not exempt of bias, it is important to be aware of the implicit assumptions that are made when choosing among those allocation rules. In the fertilizer example, the assumption that fuel consumption per hectare or fertilizer application rates are the same for wheat and maize might be flawed. Cases in which the use of allocation keys is 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 that for wheat. When looking at maize/soybean production systems realized in large parts of the United States, Brazil or Argentina, this difference is even more pronounced: soybeans do not receive any N while "neighbouring maize" easily gets treated with 200 kg/ha (app. 200 USD/ha).

Statistical and econometric techniques:

Formal statistical imputation techniques, such as "nearest neighbour imputation" or interpolation may 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 dependent on the quantities produced and that inputs are not substitutable can be used to estimate ex-post technical coefficients. These coefficients are then used to allocate costs to specific commodities. The equations to estimate the technical coefficients generally have the following form:

$$x_{ij} = c_i + \sum_{k=1}^{K} \alpha_{jk} y_{ik} + \varepsilon_{ij}$$

Where:
- x_{ij} is the quantity of input j used by farm i. This is the unallocated quantity of input purchased by a farm. This quantity is typically observed in farm surveys;
- y_{ik} is the quantity of commodity k produced by farm i, also observable;
- α_{jk} is the quantity of input j necessary to produce one unit of commodity k, also referred to as the technical coefficient in j. These coefficients, unobserved in this equation, can be estimated by regression techniques;
- c_i is a constant term, which can be interpreted as the minimum fixed amount of input j necessary for farm i to operate (such as electricity needed to heat buildings and basic maintenance expenses);
- ε_{ij} is a random error term.

Note that this equation simply formalizes the fact that the total amount of input consumed by a farm should be equal to the sum of the input uses across all the activities of the farm. If α_{jk} was observable, the equation would be a simple accounting equation ($\varepsilon_{ij} = 0$ for all i and j).

This technique, similar to any other, is prone to errors. The use of advanced statistical techniques, such as maximum entropy estimation, helps eliminate the most obvious ones, including, among others, negative technical coefficients and estimate outside reasonable bounds. In any case, these approaches should be implemented with care and, before being published, the results generated should be compared across years and countries to check their reliability.

Good practices:

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. A short summary of good practices is provided below. More detailed and input-specific guidelines are given in table 5.1.
- Respondent-based allocation (or self-allocation) should be used in priority for the less complex cost items and reserved to respondents with reasonably advanced recordkeeping practices;
- For the allocation of machinery expenses, combining information on machinery use, such as the number of hours of use or land area covered, with engineering data, such as fuel consumption per hour of use or hectares covered, will likely lead to more accurate results;
- Allocation keys should be related to the nature of the expenses to be allocated. This may involve grouping together expenses according to use. For example, when allocating non-specific farm machinery expenses, the

statistician could group together fuel, lubricants and repair and maintenance expenses. These expenses, when grouped together, 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 non-specific fuel and tractor expenses. Regarding non-specific livestock expenses, an appropriate allocation key might be the number of each type of livestock raised. However, the statistician should not 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, property taxes and insurance, 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 or gross commodity receipts can be used to allocate these types of expenses.

TABLE 5.1
List of inputs, allocation methods and associated assumption

Cost item to be allocated	Allocation between	Allocation methods	Restrictive assumptions
Fertilizers and plant protection inputs	Crops	Crop-specific application rate	Depends on the rate and its use, for example if it is region-specific but applied uniformly across all regions
		Planted area	Same application rate across crops
		Production quantity	Same application rate/yield across crops
Machinery and farm equipment (depreciation) Fuel and lubricants Electricity and heating	Crops, livestock and crops/livestock	Specific use factors, such as time/days of use, combined with engineering data, such as tractors and water pumps	Depends on the parameter itself and its use, for example if it is machine-specific but applied uniformly for all machines of the same type, such as tractors.
		Planted area	Same frequency/intensity of use, etc. across commodities. If it is a harvester then harvested area should be used and not planted area
		Harvested area	Same frequency/intensity of use, for example, across commodities.
		Cattle heads	Same frequency/intensity of use, for example, across cattle types.
Buildings (depreciation)	Crops, livestock and crops/livestock	Production quantity	Use, such as space occupied, function of quantities produced. This can only be used for commodities of the same type.
		Production value	Use function of value-added. Price differences may not reflect differences in the use of the building by the activity.
		Number of livestock (headcount)	Use function of cattle heads.
Labour	Crops, livestock and crops/livestock	Specific labour intensity factors by task, such as days and weeks	Depends on the rate and its use
		Planted or harvested area	Same labour intensity across crops
		Cattle heads	Same labour intensity across cattle types
Feed	Livestock	Feed rates by cattle type	Depends on the rate and its use
		Cattle heads	Same feeding rates for different cattle
		Cattle value	Same feeding rates for different cattle, same unit price
General management expenses Taxes, insurance, permits and licences, among others.	Crops, livestock and crops/livestock	Net or gross margins, gross value of production, area in crops production	Time spent on management, etc. function of value-added

Source: Authors, 2014.

5.4 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 seed, fertilizer and plant protection, can generally be unambiguously attributed to the commodity production process. This is not always the case for inputs that are applied or consumed by farm machinery and equipment, such as fuel for farm machinery and equipment, electricity for buildings and water for irrigation.

The method used to collect the basic data and estimate the costs depends on whether these inputs have been purchased (from, for example, farm supply establishments, other farmers or government agencies) 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 is owner supplied, then it should be valued as if it was purchased from the market. This is the price that the owner would have paid (opportunity cost) if he chose to purchase the input on the market rather than supply his own product;
- In cases in which volumes or prices of the input are not available, then the production values can be inferred from farm expense records. Adjustments may be needed to ensure that the expenses match the production period;
- 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 involves making assumptions (based on common farming practices in the area) on technical coefficients, multiplying typical input volumes by the local market price for the input in question.

In some cases, farmers pay for inputs by bartering a share of their production. This is more common for rented land, specialized labour and custom farming operations but could in practice be used as a form of payment for any input. When this is the case, the correct valuation is to estimate the value of the share of production exchanged by using the market price that the farmer would have received had he sold the product in the market.

Sometimes farmers leave part of their land fallow to restore the productivity of that land in the following year. When this occurs, costs incurred on this fallowed land should be included and attributed as part of the cost of production. The expenses of maintaining and working the fallowed land should be estimated and charged against the cost of production using the pre-productive cost methodology described below or by including the area and associated costs of the fallowed land with the planted area of the crop in question.

Lack of standardization and differences in quality for inputs increases the difficulty to collect and classify the data and carry out estimation. 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.

Most data estimation issues are specific to the individual input. This manual does not provide an exhaustive list of input variables and potential solutions, but it presents a few of the more significant input variables below along with typical situations, estimation problems and solutions.

5.4.1 Fertilizers
Scope:
Purchase or use (if owner supplied) of organic or mineral fertilizers. 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, making them easier to value than organic fertilizers. Organic fertilizers are generally owner supplied. Among them are farm waste, household waste, manure and compost. 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 have an economic value (and therefore a price) in cases in which a market exists for those inputs. For example,

if it is possible to sell them to neighbouring farmers. The costs related to the application of those inputs are ideally recorded under the appropriate cost items, such as labour costs and fuel.

Recommended 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, for example, kilogram or bag), either purchased or owner-supplied. The market price at the time of the application of the inputs is used to value the quantities in order to obtain an estimate of the costs. The costs are then adjusted to a common reference period using an appropriate inflation rate and, possibly, time-discounting factor.

Other approaches:

If information is available only on the quantities of fertilizers purchased and not used and if it is common practice in the region or country for farmers not to stock those inputs, then the cost estimate can be computed by multiplying the quantities by the appropriate market price, as explained above.

If information is only available for the value of what was purchased (not the quantities), then the cost can be estimated by adjusting the value to the chosen reference period.

If the information collected is too scarce to provide reliable estimates, a standard commodity and region-specific application rate (kilogram 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 are explicit policy rationales related to the need to collect information on nutrient quantities for fertilizer use. One of the reasons is its importance for environmental sustainability analysis: the nutrient cycle has a major bearing on measuring greenhouse gas emissions from agriculture. Data at this level of detail are 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 adequate resources and expertise, 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 those technical specificities: sometimes, fertilizers are known only by brand names.

Example: Information was collected from a farm on the amount of purchased and owner supplied fertilizer used during the cropping year: 1,000 kg of urea was purchased and 100 kg of compost was produced and used on the farm. As no information was available on the timing of purchase and application of the fertilizer, it was assumed that the fertilizer was bought during the month preceding the growing season (March to September in this example) and that all of the inputs purchased or produced on the farm were used during the growing season. The market prices were USD 300 per metric ton for urea and USD 50 per metric ton for compost at the time of purchase or use. The reference period for the CoP calculation 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 percent. The estimated fertilizer cost is calculated in the following way:

Cost = (1+2%) * [(1*300) + (0.1*50)] = (1.02) * [300 + 5.0] = USD 311

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

5.4.2 Plant protection products

Scope:

This item represents pest and weed control achieved primarily through 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, such as physical removal of weeds. Given their predominance, the focus in this section is on chemical pest and weed control. This included the use of insecticides, fungicides, herbicides and fumigants. As per the recommendation for fertilizers, costs related to the actual application of those chemicals should be excluded and recorded under the appropriate cost items whenever possible. Only the purchase costs should be included in this item.

Recommended approach:

Information is collected at the farm level on the quantities of pesticide or herbicide used throughout the growing or calendar year according to the unit that the product is either purchased or applied. The market price at the time of the application of the inputs is 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, a time-discounting factor. Other approaches are similar to what is cited for fertilizers above.

Specific measurement issues:

The valuation of chemicals for pest and weed control is relatively straightforward as they are mostly purchased. As for 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 and mixed application with planting material. The application costs should be allocated to each of the relevant items whenever feasible, for example, labour and machinery costs when machines or other farm equipment are used.

5.4.3 Planting material (seed)

Scope:

This item includes seeds (nuts), seedlings, cuttings, slips, tubers and spawn. They can be purchased from other farmers or from private sellers, provided by the government or farm supplied (or farm saved). The costs associated with seeding should be accounted for in the appropriate cost item, such as labour or machinery, if feasible.

Recommended approach:

Costs can be estimated by multiplying the quantity used by the unit price paid to purchase seed, adjusted to the reference period. If unknown, quantities can be inferred by multiplying standard seeding rates by the sowed area. Use of this inference is also a way to verify if the data reported by the farmer on quantities of seed are consistent with the seeding rates observed in the region or locality for the same crop. Usually there is not a market for farmer-saved seed. Indeed, in many countries it is forbidden to market farm-saved seeds. In those circumstances, the value of commercial grain can be used to represent the opportunity cost for the use of farm-saved seed. In practice, farmers tend to use both commercial and farm-saved seeds.

Other approaches:

Expenses for seed and other planting material reported by the farmer can also be directly used to estimate costs after the appropriate adjustment is made to the reference period. If information on quantities or unit prices/expenses is not known by the farmer, then expenses can be imputed by using standard seeding rates and market prices. This, again is subject to the existence of a market for the seeds.

Specific measurement issues:

Actual seeding rates may vary considerably from standard rates, which makes it difficult to validate the information reported on seeds. Data on quality and technical characteristics of seeds are needed to help farmers determine which technology to adopt, for example the share of high-yielding/hybrid varieties as well as the use of genetically modified varieties.

5.4.4   Animal feed

Scope:

Animal feed is comprised of purchased animal feed products, such as feedstuffs blended from various raw commodities, including, among others, maize, soybeans and oats, additives, and feed produced on the farm and fed to animals. The cost associated with delivering feed to the animals is best accounted for in the relevant cost items, such as labour and machinery, if feasible.

Recommended approach:

Costs can be estimated by multiplying the quantity of feed used by the unit price paid for the feed adjusted to the reference period. If the farmer supplies his own feed, then it should be valued at the price he would have paid to purchase similar feed in the market place.

Specific measurement issues:

Markets for farm-produced feed such as straw may be very thin or non-existent, impeding the availability of market prices needed to impute costs for owner-supplied feed. Feed costs for animals that are sent to pasture can be valued at the market price (often a per number of head fee). For own pasture, the price to use would be the amount the farmer would receive if he were to let out his land to others for animal grazing. If this is not available, then the use of the pasture land can be valued at rates charged in the local area if he were to pasture his animals on commercial grazing land.

Example 1

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 on the same agricultural holding. The average price of the maize-based meal for the preceding year was USD 200 / tonne. As there is no market for corn silage, the price used is an estimate based on the price of grain: USD 25 / tonne. The annual inflation rate is 2.5 percent. The estimated feed cost is:

Cost / year = (1+2.5%) * [(500*200) + (150*25)] = (1.025) * [100,000 + 3,750] = USD 106,344

The number of cattle fed is 250 head. The feed cost per head is therefore:

Cost / year / head = USD 425

Example 2

Assume now that monthly market prices for animal feed is available and that the feeding rates are uniformly distributed over the year (500/12=41.67 tonne/month). Monthly inflation rates are also available according to the information provided in the table below:

TABLE 5.2
Feed prices in nominal and end-of-period prices

Months	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Meals price (USD/ton)	185	185	185	185	205	205	205	205	210	210	210	210
Current month value ('000 USD)	7.71	7.71	7.71	7.71	8.54	8.54	8.54	8.54	8.75	8.75	8.75	8.75
Inflation rates, %	0.20	0.20	0.10	0.20	0.20	0.30	0.30	0.20	0.20	0.20	0.20	0.20
Dec. value ('000 USD)	7.86	7.86	7.79	7.86	8.71	8.80	8.80	8.71	8.93	8.93	8.93	8.93

Source: Authors, 2014.

The total cost is:

Cost/year = 7,860 + 7,860 + … + 8,930 = USD 102,110

And the cost per head:

Cost/year/head = USD 408

The costs of maize-based meals is slightly lower in example 2 (USD 102,110) than in example 1 (USD 106,344) because the inflation adjustments are done on a monthly basis: the annual inflation rate is applied to the value of feedstuff used in January, the February to December rate is used to adjust the feed value for February and so on. In example 1, the annual inflation rate was applied to the full value of the feedstuff used, implicitly assuming that all the feedstuff had been used at the beginning of the year.

5.4.5   Other purchased expenses

For reliable CoP estimates, it is essential that all costs and expenses are accounted for. In many cases, farm records combine several smaller (in terms of value) expenses items. Farm practices and conventions vary considerably by farm type and across countries, making it impossible to list all of the possible items and specific approaches for estimation for each one. It is always preferable to separate these costs if possible so that comparisons can be made with other CoP computations. The preferred approach is to value quantities used by the price paid indexed to the time period under consideration.

5.5 ESTIMATING THE COST OF CAPITAL GOODS

Capital goods:

For the purpose of the Handbook, a capital good (alternatively called capital asset or capital input) is defined as an input into the production process that is not used up during one production period. Capital goods[12] can be in the form of farm buildings or structures where production takes place, machinery and equipment[13] 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 (fruit or coffee are but two examples) as well as livestock used for breeding or used to obtain

---

12 This section differentiates capital goods (such as buildings, tractors and other farm machinery) from financial capital, which can be placed into investment accounts or other financial instruments.

13 This ranges from large to small farm equipment, including a multitude of tools used by farmers. For practical purposes, farm equipment that costs less than 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.

livestock products (milk) are also considered to be capital because they generate a flow of services over multiple time periods. As capital goods are not entirely consumed during the production year, it is necessary to allocate the cost of the capital good to the production years for which they provide this service.

Capital costs:
They include the costs associated with the ownership of capital and are essentially of two types: depreciation costs (the reduction in the useful service life of the capital good) and the opportunity cost of the investment in the capital. Additional costs associated with the ownership of capital include property taxes, insurance expenses, licences and fees. While associated with capital, expenses of this type should be accounted for separately under the specific item "insurance premiums", "taxes" and so on.

> **RESIDUAL CAPITAL**
>
> There are other examples of inputs other than machinery and buildings that can yield benefits beyond the current production period. This is the case for some types of fertilizers. For consistency purposes and because of the complexity needed to identify the nature and extent of these carryover effects, it is not recommended to treat these inputs as capital assets. Significant improvements to the land, such as terracing, or to its characteristics, such as fencing and fixing wells, should be considered as part of the capital used in farm production.

5.5.1 Consumption of fixed capital (depreciation costs)

Depreciation cost estimates attempt to reflect the reduction in the useful service life or capacity of a capital input (fewer remaining hours of use for tractors or years of productive life for tree fruit, or breeding animals). Consumption of fixed capital is normally used to describe the loss of productive capacity for farm machinery, equipment or farm infrastructure (irrigation infrastructure and farm buildings). Depreciation costs can also be ascribed to permanent crops, tree plantations or to animals that need to be replaced at a certain rate, such as cacao trees or dairy cows.

Recommended approach:
The depreciation of a capital asset reflects the decline in the service life of the asset and its technical obsolescence. Ideally deprecation[14] of capital goods is best measured as the change in the market price of the capital good in question as market values theoretically 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 $P(t)$ is the market price of the asset expressed in the prices of the reference period.

Market prices for some 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 that are used should relate to an asset with a given array of characteristics that best matches the farm asset. For example, it would be best to 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 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:

---

14 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.

$$\text{Depreciation cost (t)} = \Delta P(t) * P(1),$$

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 prices for those goods are rare.

Other approaches:
In the absence of reliable market data on the capital good in question, the statistician must rely on alternative methods to estimate depreciation. 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" depreciation) which consists of allocating the depreciation of the asset to each time period in equal amounts. To calculate the amount charged against each production period, the statistician needs the cost of the asset at the beginning of the period and the known or expected life of the asset. The difference between the purchase price of the asset and its estimated value at the end of its expected life (salvage value) divided by the number of years of expected service life will equal the linear depreciation estimate:

$$\text{Depreciation cost (t)} = [\, P(1) - P(T)\,] / T$$

Where $P(T)$ is the estimated asset value 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 of the capital asset is spread out evenly over the expected life of the asset. This is not 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. An example of non-linear depreciation schedule for an asset with a service life of four years is given by:

$$\text{Depreciation cost (t)} = 0.45.[\, 1 / t\,], \text{ with } t=1,2,3 \text{ and } 4$$

The depreciation schedule given by this formula is 45 percent in the first year and 22.5 percent, 15 percent and 11 percent in the second, third and fourth year, respectively. By the end of the fourth year, the asset has been depreciated by a total of 93.5 percent. Note that using this formula results in a situation in which 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 to the purchase price of the asset. This method suggests that depreciation is not the same in each year: the depreciated amount decreases each year. It has the disadvantage that the asset will never be "used up" entirely. This disadvantage becomes negligible when the asset's service life is large[15]. It is preferable to limit the use of this approach to capital assets with a long service lives, such as buildings.

---

15 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 $\lim_{\to +\infty}(1-\alpha)^{t-1} = \frac{1}{\alpha}$ that $\lim_{t \to +\infty} A = 0$.

A different family of methods exists to estimate capital. They entail measuring the portion of the capital that needs to be put aside each year to account for depreciation and the opportunity cost that is incurred by the farmer. These techniques, while being more complex to implement, are more accurate from a farm accounting perspective. By design, they treat capital costs as the funds that should be set aside each year by the producer to ensure that the farmer will be able to purchase a similar asset on the market after the expiration of the service life of the current capital good.

In cases in which data on market prices and on the technical characteristics of the capital asset itself are too difficult to collect, such as useful service life and salvage value, capital costs can be estimated using the cost of purchasing the capital service from someone else. This approach is founded on the premise that the price charged by the service provider will cover the cost of using his own capital (both depreciation costs and opportunity costs). 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 sale of capital goods' services, such as machines, by a provider, comes with an "all in" price and includes the cost of labour and fuel. In those circumstances, it becomes difficult or impossible to identify the exact share of capital costs. Using rental rates that incorporate these additional inputs generally lead to an overestimation of capital costs.

Specific measurement issues:

In some cases, assets that are fully depreciated continue to be used. This issue, which is prevalent in developing countries, 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 for simplifying the calculation process, but if these discrepancies are significant and systematic, the parameters used to compute depreciation should be reviewed and revised 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 the result of repairs and maintenance work made on the capital asset by the farmer or external operators. Repairs that lead to an increase in the useful service life of the asset or improve its service capacity, such as a change in an engine, should be treated as an investment that prolongs the useful life of the asset and added to the value of the asset and then depreciated accordingly. Normal repairs and maintenance (tires, brakes, oil and lubricants) should be treated as an expense and not as an investment.

Another issue, which has been brought up 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 large urban or accessible regions but is often irrelevant for extrapolation to rural areas where markets are thin or do not exist, which is often the case in developing regions.

Some capital assets, such as farm buildings or vehicles, may be used for the farm itself, namely 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 completely 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, where farmers and their families 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 may use it for private purposes. In addition, expenses attached to those 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 household's private living space and fuel expenses for vehicles that are used for private purposes as well as for the farm. In such cases, household-related expenses need to be estimated and subtracted from the total estimate in order to avoid artificially inflating farm expenses.

5.5.2 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 in order to obtain a conceptually correct CoP estimation. The opportunity cost of capital represents the expected return on the 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 non-financial assets). For example, costs associated with the purchase of trees or cattle for dairy or slaughter should be accounted for as investment expenses, not as a cost. 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 separate cost item, such as "interest payments on loans".

Recommended 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. This estimate can be difficult to compute and subject to error. It involves judgment on the part of the statistician on several dimensions. First, the market price of the asset must be determined, often in situations when the markets are thin for these assets, and second, an assumption must be made on the appropriate rate of return to ascribe to that value. A general practice is to use long-term bond rates as a proxy of the average rate of return on capital.

Alternative approach:

Another approach to allocating capital to productive activity is the capital recovery approach.

AN EXAMPLE OF THE CAPITAL RECOVERY APPROACH

The United States Department of Agriculture Economic Research Service (USDA-ERS) uses the capital recovery approach, also known as the capital service cost method, to compute the annual costs of using capital assets in commodity production. To illustrate how the method is applied, consider a 30-foot row head combined with a current purchase price (PP) of USD 300,000, a useful life (n) of five years at 400 hours of use per year, and a salvage value (SV) of USD 30,000. The annual capital recovery cost is computed using the formula:

$$CSC = \frac{PP - \frac{SV}{(1+r)^n}}{\frac{1 - \frac{1}{(1+r)^n}}{r}}$$

where r is the real interest rate. The estimated long-run rate of return to assets used in agriculture is used by USDA as a proxy for the real interest rate and in this example is assumed to be 4 percent. Thus, the annual capital recovery cost of the combine is estimated as:

$$CSC = \frac{300,000 - \frac{30,000}{(1.04)^5}}{\frac{1 - \frac{1}{(1.04)^5}}{0.04}}$$

$$= \frac{300,000 - \frac{30,000}{1.21665}}{4.451822}$$

$$= 61,849$$

To allocate the cost to a specific activity, the annual cost per hour is useful. This is computed as the annual cost, USD 61,849, divided by the annual hours of use (400) to be USD 154.62 per hour. Using an engineering formula, a 30 foot combine is estimated to cover 8.4 acres per hour. Therefore, the annual capital cost of covering a 100 acre field is computed as [USD 154.62*(100/8.4)] = USD 1,840.71, or USD 18.41 per acre.

It consists in using an annuity formula in which depreciation and opportunity cost are combined. The result represents the cost (depreciation and opportunity cost) of the capital used in the CoP estimates. The annuity can be expressed as:

$$CSC = \frac{PP - \frac{SV}{(1+r)^n}}{\frac{1 - \frac{1}{(1+r)^n}}{r}}$$

where PP represents the purchase price of the capital, SV is the value of the capital at the end of the period (salvage value), r is the real interest rate and n is the number of years. The result represents the annual (constant) cost of using the asset. It assumes that the year-by-year cost is the same in real terms.

5.5.3 Owning vs. renting capital assets

Instead of owning the capital asset, the farm operator might hire the capital service. This is a widespread practice in many developed and developing countries. The development of rental markets has even been recognized as the most important strategy for mechanization of smallholders in sub-Saharan Africa (Mrema *et al*., 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 from other farmers or from specialized service providers. In many cases, the rental agreement includes the cost of machine operator labour, fuel and other items necessary to the functioning of the machine. The rental price often consists of all the services required to carry out the given task and does not generally provide a breakdown for different input costs, such as labour, fuel and the depreciation of the capital asset itself.

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 and most common approach, but it will lead to an underestimation of capital costs used by farmers who choose to rent those services. It also risks affecting the comparability of the cost structures between farmers who own capital and those who rent it. The second option is more complex to implement and inevitably requires assumptions that might reduce the relevance and quality of the data. More importantly, given that rental costs generally include 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. This should be reflected in the structure of costs.[16]

From a pure national accounting perspective, the first option is preferred as it better reflects the interactions of the agricultural sector with other sectors of the economy namely, businesses providing services to agriculture, 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 it avoids double-counting.

Further complicating the issue is that in most cases, the capital good, whether 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 consists in using the area shares allocated to the different commodities. Other methods are described in section 5.3.

In some cases, the purchase of these services might be made by the farmer with a share of production rather than in the form of a monetary payment. In this case, the cost should be estimated based on the revenue foregone had the commodity been sold in the marketplace in accordance with the opportunity cost principle.

---

16 A farmer's decision as to whether to buy or to rent capital is based not only on the opportunity cost of both options, but also on the availability of capital assets on the market and the ability to finance their purchase.

5.6 LABOUR COSTS

Labour is an essential input for most 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 advanced 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 crops in the Philippines is provided in Graph 5.1.

The collection of information on labour inputs and the estimation of related costs should, therefore, constitute an essential component of any statistical programmes on CoP.

The diversity of labour contracts and agreements set on the farm, especially in 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 retribution either in kind or in cash 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, a contractor might pay employees individually or collectively. 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, namely labour provided by another farmer or employee of a farm in exchange for a service.

GRAPH 5.1
Share of labour in total production costs for different crops (Philippines, 2012)
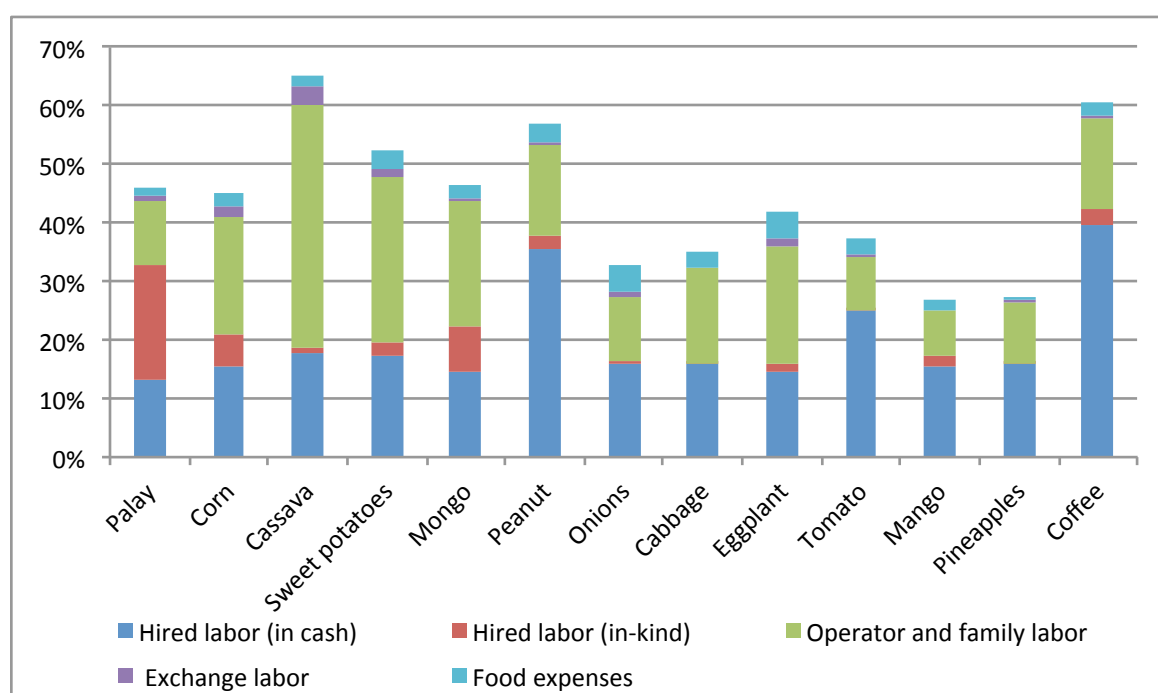
Source: CountryStat - Cost and Revenues Survey, 2012.
Note: Food expenses represent the value of food provided to hired workers.

5.6.1 Hired labour

Scope:

Estimates for hired labour should represent the total cost of payments for paid labour used to assist with the production of the commodity and include all activities, from low-skilled labour to management work. Labour costs comprise all salaries and wages, including in-kind payments, as well as all payroll-related taxes and social contributions (social security, pension, health and life insurance) paid for by the employer. Taxes and contributions paid by employees should be excluded. Any in-kind compensation, such as the provision of free or subsidized meals, lodging or a share of production, should also be accounted for in hired labour costs and appropriately valued. Conceptually, 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, those 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.

Recommended 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 allocating labour costs across the different enterprises and activities within the farm.

In-kind payments should be valued at the price that the products would cost if purchased in 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 had he sold the product in the market, namely the farm-gate price, and added to labour costs. If the employee can purchase a product at a reduced price, 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, should be added to hired labour cost. Similarly, average lodging rental fees in the locality can be used to value on or off-farm lodging provided by the employer and a standard price of a meal taken outside the 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 completely as possible all of the components of remuneration, of which monetary retribution represents only one part and in some cases only a minor component of labour costs (see labour costs for palay, Table 5.3).

In cases in which wage rates cannot be easily determined or when the information reported is unusable or simply missing, average wage rates can 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, seeding, management, etc.) and farming subsectors. 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 subsector. An illustration of sector differences in wage rates is given by BAFP (2012) for South Africa, where average wage rates ranged from less than 300 South African rand (R) for pineapple production to above R1200 for sugar cane and citrus fruits. The ability to use detailed wage rates depends on the existence of labour markets for workers in the different subsectors.

Additional challenges with the estimation of hired labour costs are created by the difficulty of determining, with the appropriate level of accuracy, the quantity of labour used. This is the case, for example, for workers hired to carry out a given task 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, the farmer does not necessarily record information on the time spent by the workers.

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, such as different crops, dairy or cattle, 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 allocation keys can be used (see section 5.3).

Depending on user needs and the CoP 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, 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 have to be used. The allocation procedure depends on the amount of information available and the farm type and activity. On the other hand, collecting data on labour use and costs by tasks may be more adapted to the actual expenses of the farm and to the capacity of the farmer-respondent to respond. This is the case if the tasks are well differentiated, separated in time and undertaken by different types of workers. A good example of this is the questionnaire for collecting data on production costs for coffee in Colombia: it is structured according to the different tasks that have to be completed in a coffee plantation.[17]

Different cases can be distinguished:
- 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 and to administrative tasks, among others. If the farm is involved in the cultivation of different crops, 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 (see section 5.3). In the case of mixed farming in which 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, such as labour costs associated with harvesting and farm management, ratios derived from previous surveys or studies that determine the quantity of labour required to perform an activity can be used. The quantity thus obtained can then be valued using an appropriate price.
- Labour costs are distributed across their main sub-items, such as harvesting and seeding, but they are not apportioned according to the different crop enterprises. In that configuration, 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 can be used.

Example:
Consider a farm involved in the cultivation of two crops 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 the first crop is USD 9,750 (70 percent of the gross revenue of the farm, farm-gate price of USD 390/ton) while for the second crop it is USD 4,250 (30 percent, farm-gate price of USD 85/ton). The activities directly related to cultivation (seeding, land preparation and harvesting) required 63 days of work in the case of crop 1 and 19 for crop 2, at a daily rate of USD 8. For the remainder of hired labour costs, which represent 20 additional days, neither the commodity to which they are related nor the nature of those costs (for example, repair and maintenance) are distinguished. Finally, the farmer distributed for free to its regular employees 50 kg of crop 1 and 25 kg of crop 2 as in-kind compensation.

---

17 The CoP programme for coffee in Colombia was one of the three case-studies that were carried out for the field test of the draft handbook.

<u>Crop 1</u>

Hired labour costs directly related to the cultivation (land preparation, seeding and harvesting) =
63 days * USD 8/day = USD 504

Other hired labour costs = 70 % of revenue * (20 days * USD 8/day) = USD 112

In-kind compensation = (50 kg*USD 39/kg) = USD 19.50

Total hired labour costs = 504 + 112+ 19.5= USD 635.5

<u>Crop 2</u>

Hired labour costs directly related to the cultivation = 19 days * USD 8/day = USD 152

Other hired labour costs = 30 % of revenue * (20 days *USD 8 /day) = USD 48

In-kind compensation = (25 kg *USD .085/kg) = USD 2.1

Total hired labour costs = 152 + 48+ 2.1 = USD 202.1

5.6.2   Unpaid labour

Unpaid work by the farm operator, spouse or any other family members, including work done by children to perform tasks directly or indirectly linked to the production process, should be treated in the same way as hired labour (see previous paragraph). While unpaid work can also be provided by non-family persons who have ownership rights for the farm (often family relatives), community labour (without exchange), guest workers and other unpaid workers, the focus of this section is on unpaid family and operator labour, given their predominance in total costs for unpaid labour. The estimation methods that are presented can also be applied with some adaptation to other forms of unpaid labour, except in very specific situations in which opportunity costs are difficult to determine.

Recommended approach:

Unpaid family labour should be valued using the opportunity cost principle: the corresponding wage rate that the unpaid family member would receive in the labour market with paid employment that corresponds to his "next best alternative". The nature of the job and salary that a family member might obtain so that an opportunity wage rate can be determined is dependent on a number of factors. At the individual level, characteristics such as the sex, age, academic qualifications and professional experience of the family member will be used to determine a potential wage Also, the existence of employment opportunities in sectors other than agriculture, such as industry and services, are important considerations. In some regions, the next best alternative might be relatively highly paid jobs in the tourism industry, while in other areas it might simply be another job in the agricultural sector. Estimating the opportunity cost for unpaid labour is clearly a complex, time and resource-consuming task given the number of possibilities and case specific situations. When estimates are produced using an econometric approach, the term hedonic equation is often used to characterize this method. An example of this approach by the USDA is given further below.

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 does not account for the variability in wage rates within farms. This is the approach taken by the European Union Farm Accountancy Data Network (FADN), 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 labour costs for young family workers who have few employment options. Similarly, information on wages pertaining to industry organizations, trade unions or farm extension services can be used provided that these data exist and are made available.

Certain approaches may underestimate 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 underestimation) associated with the approach adopted should be clearly identified. Regardless of the method used, upon selection, it should be applied once in a consistent way across farms and surveys and the associated documentation should be made public. As changes in methodologies may lead to breaks in time series, approaches should not be changed 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). In order to avoid an overestimation 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. 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 subsectors.

Example:
Consider the same farm as in the previous example, involved in the cultivation of crops 1 and 2 in a sequential cropping system. Recall that hired labour costs amounted to USD 202 for the production of crop 2 and USD 636 for crop 1. 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 crops. He spent his time mainly on administrative tasks, accountancy, financial planning and purchasing farm materials, equipment and inputs. His spouse provided assistance on administrative tasks and additional help during the harvest periods for a reported total of 50 days per year. Their 16-year-old child worked 10 days 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 per day, resulting in a total cost of 20 USD*250 days = USD 5,000 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: USD 13/day, namely 13*50 days = USD 650/year. Finally, the work of their 16-year-old child is valued using the minimum agricultural wage: USD 6/day, namely: 6*10 days = USD 60/year.

Total unpaid labour costs - Farm: 5000 + 650 + 60 = USD 5,710 / 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 – Crop 1: [70% * (5000+650)] + (50%*60) =USD 3,985

Total unpaid labour costs – Crop 2: [30% * (5000+650)] + (50%*60) =USD 1,725

TABLE 5.3
Labour costs by type and activity

In USD	Total farm	Activity: crop 1	Activity: crop 2
Hired labour Of which:	**837**	**636**	**201**
Seeding, harvesting, etc.	650	500	150
Other	187	136	51
Unpaid family labour	**5,710**	**3,985**	**1,725**
Total labour costs	6,547	4,621	1,926

Note: Based on data on wages and yields gathered from various sources.
Source: Authors, 2014.

BOX 5.2
Unpaid labour costs using econometric estimation

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, such as age, sex and education level, 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. USDA has considerable experience using this approach with data on earnings of farm operators in off-farm employment (El-Osta & Ahearn, 1996).

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

$\widehat{wage}_i = ß_1sex_i + ß_2educ_i + ß_3region_i + ß_4age_i$

Where:

- $\widehat{wage}_i$ is the estimated wage of individual i
- $ß_1$ measures the effect of sex on the wage (such as the male vs. female premium)
- $ß_2$ measures the effect of education (such as secondary vs. high school diploma)
- $ß_3$ captures the region-specific effect
- $ß_4$ measures the effect of age
- $\hat{\alpha}$, a constant term, that 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 nonlinearities in order 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, his/her family members and on variables defining the economic environment in which the farm operates, such as region, job market and wages. 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. Instead, it is sufficient to carry out these tasks at regular intervals, such as every three or five years, or each time farm structural, household surveys or censuses are conducted. It should be noted that if macroeconomic conditions and characteristics of local job markets change at a rapid r pace in certain developing countries, more frequent updates to these models are required.

5.7 CUSTOM OPERATIONS

Scope:

Farmers can choose to supply all of the labour and machinery inputs themselves or hire others to provide similar services. Known as custom services, they can range from simple farm tillage or harvesting to virtually any and all of the farm operations. The services usually consist of hiring a combination of inputs, such as machinery together with fuel, animals for draught, labour and, in some cases, expendable inputs such as fertilizer or pesticides. Sometimes, neighbouring 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 (Graph 5.2). Moreover, the development of these markets has been recognized as the most important strategy for mechanization of smallholder agriculture in sub-Saharan Africa. Given their importance for developing countries, a close examination of how these services can be valued and accounted for in CoP estimates is needed.

GRAPH 5.2
Share of rental services in total cash costs (Philippines, 2012)
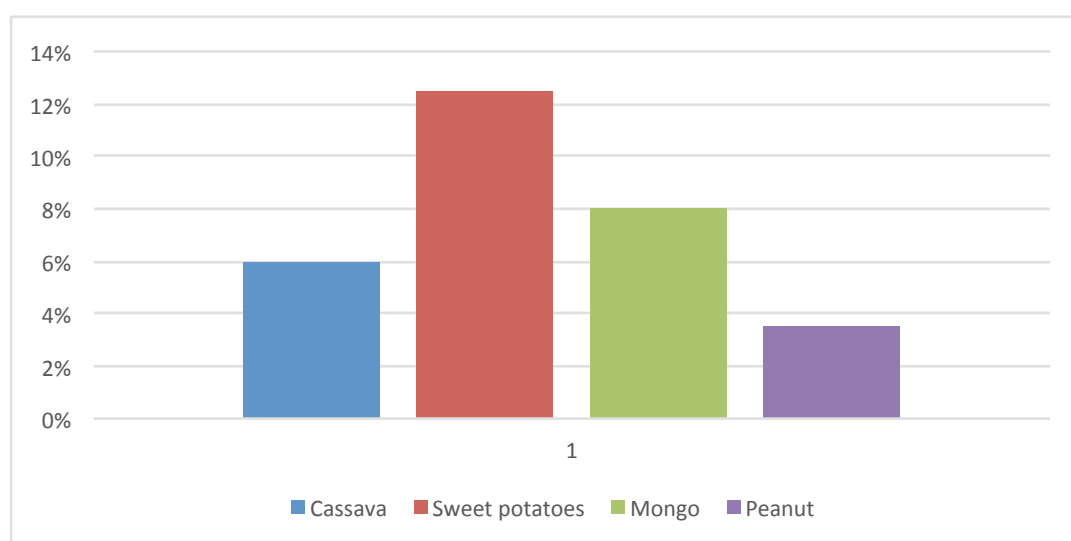
Source: CountryStat-Cost and Revenues Survey, 2012.

Recommended approach:

The general principle is that custom services should be valued at the cost, to the farmer, of the services purchased. When services are traded with a neighbour with no money exchange, 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 rests with the allocation of these costs to each specific cost item and to each of the activities of the farm. Custom services generally include the provision of a combination of input items, such as machinery, fuel, labour, fertilizers and pesticides. For some analyses, it is preferred that these expenses are itemized and recorded separately. This is to enable the analyst to compare the use of these inputs across other farms, including those that do not use custom services. It is also necessary to appropriately estimate total factor productivity and to ensure complete and adequate coverage when constructing satellite accounts for agriculture especially to identify 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 5.3. In cases in

which expenses associated with the hiring of these services are small relative to other cost items, namely less than 5 percent of cash costs, they can be grouped under a unique item, other expenses – custom services.

In cases in which these services are not purchased but are provided at no charge or as part of an exchange agreement with other farmers, the opportunity cost should 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 two-hectare maize field during the cropping year. He recorded the total amount paid, USD 1000. This amount included the expenses related to the application of fertilizer, such as machinery and equipment, fuel and the operator but did not take into account the purchase of the substances themselves, which were previously acquired by the farmer.

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

One operator has carried out the fertilizer application over two days. 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, 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 that of 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 USD 10 per hour is assumed. The total labour cost related to fertilizer application for this farm is therefore USD 160, USD 80/ha. This amount has to be recorded as labour costs, as it would have been if the farm operator or one of his employees had carried out the application.

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 equations are usually available in specialized reviews. The Handbook of the AAEA Task Force on Commodity Costs and Returns (2000) provides details on this. For example, assuming that a tractor with a maximum horsepower per hour of 100 was used for the fertilizer application, for a total of four hours, the total diesel consumption amounts to approximately 175 gallons. Using an average price per gallon of USD 3.5, estimated fuel costs amount to USD 613, or USD 306.5/ha.

Total or part of the residual cost (USD 1000 -USD 613 -USD 160 = USD 227) can be recorded as capital depreciation, as it can be assumed that if private contractors act rationally those 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) = USD 80 (USD 40/ha) => fertilizer costs
Custom costs – labour = USD 160 (USD 80/ha) => labour costs
Custom costs – Fuel = USD 612(USD 306/ha) => machinery and equipment
Custom costs – Other = USD 227 (USD 113.5/ 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 on their own in contrast to, for example, fertilizer application, seeding or harvesting. Given their specificity, these costs are often recorded separately. They should include medications and supplements administered to animals. Some examples include administered vitamins, hormones and, medications used to counter external and internal parasites. Veterinary fees and costs associated with products (needles, gloves and other supplies) 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, such as number of visits, by unit prices or 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.

5.8 LAND COSTS

Scope:

Land used in the production of agricultural products is unique in that unlike variable inputs, which are typically used up within one production cycle, or unlike capital inputs, which generally wear out and therefore have a finite service life, the service provided by land 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. Infrastructure 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 others relate to the right to use the land itself.

When computing 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 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 is water use charges.

Land improvements that provide a service to multiple production cycles should be classified as capital and treated accordingly. This includes 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, fences and irrigation systems. Additions to land that are necessary for certain crops, such as tree planting for orchards, should be treated as other preproduction costs (see section 5.9). This treatment of land improvement expenses is in line with the new European System of National and Regional Accounts (ESA, 2010), which recommends the creation of one additional asset class to include land improvement actions, such as wells and, terraces, 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.

Recommended 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 landowner 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, namely the producer price. In Canada, for example, farmers renting land on a "share crop" basis generally give one third of their harvest to the landowner. This ratio varies according to characteristics, such as the type of crop being cultivated, the region and the proximity of the land to urban centres.

Owned land can be estimated using two main methods. The first one, theoretically appealing, is to estimate the opportunity cost for the farmer holding the land, the foregone revenues to the operator had the value of the land been invested in its next best alternative. The market value of the land multiplied by the imputed interest rate reflects the true cost to the farmer of using the 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 is not necessarily within the range of returns of the possible alternative investments.

Given these limitations, the costs associated with the use of owned land can be estimated by local land rental rates, that is, the price that would have been requested had the land 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 relationship between the rental value of land to characteristics, such as the quality of the land (for example, orientation, slope or, irrigation.) or its proximity to urban centres (which might increase its value). 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. However, 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.

There are too many other issues related to land use for the Handbook to list and suggest recommendations for dealing with them. Countries should follow the general principle that the opportunity cost of owned (non-rented) land cost is valued using the local area rental price, and that special situations be addressed according to a country's specificity. Examples of special situations include communal land, and communal ownership of the products of trees, but not the land itself.

Specific measurement issues:
In some countries, rental agreements are subject to administrative regulations imposing predefined ceilings on rental rates. Where rental markets are non-existent or too thin to provide reliable estimates, those 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 in which 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 better reflects the actual cost but would also lead to results inconsistent with the legislative requirements and would expose its lack of enforcement. To obtain valid cost of production estimates, the price paid by the farmer is the appropriate price to use.

Example 1:

The farmer rents the land. The farm produces wheat on 10 hectares of rented land. The annual rent is expressed as a percentage of the total wheat production during the cropping year, 25 percent 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 USD 5,100 or an average unit price of USD 300 per MT of wheat. The annual rent paid by the farmer for the 10 hectares can therefore be estimated at 4.25MT * USD300 = USD1,275.

Example 2:

The farmer is the owner of the land. The farmer owns a five 5-hectare plot where he grows coffee intercropped with chili pepper. The very few transactions involving agricultural land in the locality impede the use of market prices to value land and use of 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 USD500/MT and USD4,200/MT, respectively, the imputed rent is: [1/3*(USD500*10)] + [1/3*(USD4,200*3)] = USD5,867 or USD1,173 per hectare.

5.9 PREPRODUCTION COSTS

Scope:

Preproduction costs (also called establishment costs or establishment expenses) are costs 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 (2000): "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 percent)" (p.6).

These expenses can be incurred for commodities that are produced or harvested entirely within a single year (single-year enterprise, such as trees) or over several years (multiyear enterprises, such as perennial crops, fruit tree, vineyards and dairy cows, among others). To obtain relevant and comparable cost and revenue estimates, preproduction 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 or any joint product that takes place during the pre-productive years, such as banana trees planted on cacao plantations, should be recorded and deducted from the costs. More formally, preproduction 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 preproduction costs incurred in the pre-productive period
- H is the length in years of the preproductive 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

5.9.1 Case 1: production occurs entirely in a given year

Approach:

The first step is to identify the beginning of the preproductive period, namely 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 preproduction costs should be recorded and valued in current monetary units and adjusted for inflation to the reference period, for example, the end of the production year. Ideally, the preproduction expenses should also be adjusted for the annual cost of carrying those expenses, namely 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 is harvested.

5.9.2 Case 2: production extends over several years

In this situation, the preproduction 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, preproduction costs are allocated over the productive years applying the same approach used to depreciate capital assets. Annual allocation of 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 represents the annual portion of establishment costs that needs to be allocated against each year of production
- PPC represents the total preproduction costs incurred in the preproductive period
- H is the length in years of the pre-productive period
- N is the productive period in years of the enterprise
- SV is the salvage value at the end of the production period

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:

$D_t=D(1+i)^t$ *for all t=1,…,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 of a depreciation schedule (be it straight-line or something else) that reflects the actual changes in value.

Cost Recovery (or Annuity) Approach:

As with the traditional budgeting method, the cost recovery approach consists of accruing annual preproduction costs to a future value at the end of the preproductive period and allocates this amount over the productive years of the enterprise. The difference lies in the fact that this accumulated total is amortized over the production period using an annuity formula. Thus, there is 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:

$$A = \frac{PPC - {SV}/{(1+r)^{N-H}}}{\frac{1 - {1}/{(1+r)^{N-H}}}{r}}$$

As in the traditional budgeting approach, the amounts charged to each production year need to be adjusted for inflation: $A_t = A(1+i)^t$ *for all t = 1,..., 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 Helmers, 1981) and when flows occur over time (Walker and Kletke, 1972), 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 (or is assumed) to be operating at equilibrium, characterized by a fixed asset base, such as number of planted hectares or number of cattle heads, constant replacement rates, such as percentage of hectare of new plantation or percentage of new cattle heads and fixed relative establishment costs. These methods have the advantage that they are simpler 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 of determining preproduction costs as a share of current costs. This share is based on the steady state replacement rate for farm assets: (10 percent of a herd may need to be replaced annually to maintain a stable number of cattle or 25 percent of the land may need to be replanted annually to maintain a constant level of production for crops, such as alfalfa, which requires a one year preproductive period followed by four productive years.

Concretely, the calculations are done in two sequences. The first sequence consists of determining the ratio of preproduction costs to current costs, assumed to be fixed for a given time period under the assumption of fixed technology (steady-state or equilibrium): preproduction costs 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 those assets. This operation can be done with data spanning a sufficiently large time period, such as an average of three years, to reduce the risk that "outlier observations" might distort the ratio. The second step is to apply this ratio to the estimated annual current costs with the resulting amount charged against production for the corresponding year.

The market value approach:

This approach is very similar to the current cost method with the only difference being that estimates of preproduction costs are estimated by using the market value of the preproduction assets. For example, market values for replacement animals are used to estimate preproduction costs for a livestock farm, as opposed to building up the actual costs associated with livestock breeding herd. 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 this case, the historic cost (or raised value) method may be used.[18] Market valuations might also be biased towards future earnings and not historical costs.

Example:

Estimation and allocation of pre-production costs for a 20 hectare cocoa plantation.[19] The following assumptions are made:
• Average yield for the productive years: 306 kg of cacao beans per ha;
• Selling price: USD 4,000 per MT;
• Annual inflation rate: 15 percent

---

18 See AAEA (2000), section 10-19, for further details on this approach..

19 Data and parameters used in this example are taken from a variety of sources (FAOSTAT, International Cocoa Organization, Cámara Venezolana del Cacao, Gobernación del Huila in Colombia). The calculation and allocation of preproduction costs are the sole responsibility of the authors.

- Length of the preproductive period: 4 years;
- Yield during the per-production period (as a percentage of the average yield for the productive years): 0 percent in the 1st year, 5 percent in the 2nd year, 40percent in the 3rd and 60 percent in the 4th year;
- Average CoP for the productive years: USD 2.0 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 5.4) and net returns, including allocated establishment costs (Graph 5.3).

TABLE 5.4
Pre-production costs for 20 hectares of cocoa plantation

Year	Production (ton)	Returns (USD, nominal)	Costs (USD, nominal)	Net returns (USD, nominal)
1	0.0	0	33,048	-33,048
2	0.3	1, 224	13,464	-12,240
3	2.4	9, 792	12,852	-3,060
4	3.7	14, 688	12,240	2,448

Source: authors based in information from different organizations, 2014
Note: Using the formula presented above, total preproduction costs are estimated as pre-production costs = USD 67,520

GRAPH 5.3
Net returns with allocated establishment costs (USD per ha in nominal prices)
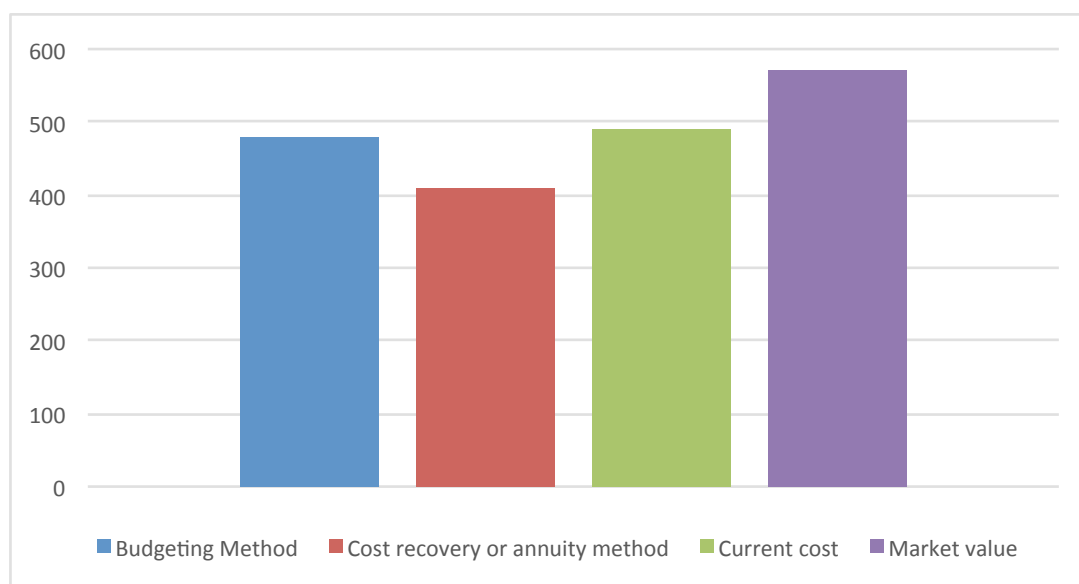
Sources: Multiple (FAOSTAT, International Cocoa Organization, among others), 2014.

5.9.3 Allocation of revenues and associated costs from joint products

Allocation of revenues and costs for joint products:

It is common in agriculture production to have activities that 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 with dairy farms when the primary product is milk but the farm also produces calves and culls cows (meat production) as a by-product of the milk production. Another example is a cow-calf farm in which the main objective is producing a weaner calf,[20] but similar to dairy farms, there are side products, such as cull cows, cull heifers or heifers sold for breeding. Making comparisons on a "'per weaner" basis would only produce distorted results if the proportion of weaner sales to total sales varies significantly between the farms. There are three options to deal with this issue:

- Refer all returns and costs to the main product and produce a chart highlighting the composition of the returns by main product and side product to make the issue transparent. This would be appropriate for milk CoP but it would overestimate the costs and returns for the production of only milk.
- Refer all returns and costs to the total weight produced (weaner calves, cull cows and heifers, breeding cattle). This is most appropriate in cow-calf production and products reflected here can be considered more closely related than the milk and the meat in the dairy enterprise.
- Calculate the cost of milk production only or costs of weaner production only by deducting the returns received from the joint product(s) from total costs. This will yield an accurate cost for the product of interest but has two flaws:
    - It assumes that the value of the joint product is equal to the cost of producing the joint product.
    - It works for total costs (from which the total returns of by-products are deducted to obtain one figure of reduced total costs) but not for expense item 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, 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 cost of production accounts for each commodity.

5.9.4 Allocation of input costs for intercropping or mixed cropping systems

Mixed cropping is a cultivation practice in which two or more different crops are grown simultaneously in the same field. Intercropping, which is a special case of mixed cropping, occurs when a crop is planted between the rows of another crop, such as sorghum between cotton rows or sorghum between groundnut rows, or groundnuts between maize rows. The most common goal is to generate a greater yield by making use of the resources, such as land or organic matter, that would otherwise not be utilized in a sole cropping system. Intercropping is also used to extract synergetic agronomic benefits. Other intercropping systems exist, such as row cropping or relay cropping.

Allocating input use and costs in mixed cropping systems is particularly complex because:

- The area of land devoted to each crop is difficult to determine, which complicates the allocation of inputs, such as fertilizers and plant protection products, labour and machinery applied on per hectare basis.
- Given the agronomic benefits that can be expected from intercropping, it is also not advisable to use standard application rates for fertilizers or other inputs that are usually based on sole cropping systems.

---

20 A weaner calf is a calf no longer fed with its mother's milk and ready to adopt an adult diet.

As with many of the recommendations of this Handbook, there is no unique and ideal method to distribute inputs costs for mixed cropping systems. Once the method is chosen, it is important to apply it consistently and ensure transparency for the data user. Among the methods that can be chosen, the statistician can rely on:

- The apportionment of area under crops in mixture may be approached by asking the respondent what proportion of the field would be covered by each crop (the inputs used to grow each crop can be allocated according to the land planted to each crop. Thus, the area under each of the crops in mixture will be equal to the area of the field);
- Published industry standards, field trials and expert opinions;
- Mixed cropping systems are multi-input multi-output farming systems. Modelling approaches, such as the one presented in section 5.3, in which crop-specific technical coefficients are estimated on the basis of observed crop output and farm-level input use, can also be used; The statistician can also decide to refer all returns and costs to the main crop, if there is one, and deduct from its production costs the revenues generated from the sale of the secondary crop. Cost and margin calculations can be biased if there are significant differences in yields and profitability between the two crops. It also renders the results for the main crops sensitive to output price variations in the secondary crop.

6
Disseminating and presenting data on cost of production

Ultimately, the purpose of conducting cost of production surveys is to provide information to the many different stakeholders involved in the sector so that overall national efficiencies can be increased. As noted in Chapter 2 on users and uses, the scope for augmenting efficiencies can be in the form of improved decisions taken by producers or enhanced knowledge transfer through extension services or greater efficiency in developing and delivering government policy, just to mention three examples.

There is little to be gained by not releasing collected data. Unnecessarily withholding collected information results in strained relations with respondents and users alike. This can have long-term negative consequences for not only the future of the particular data survey or programme but also for the entire statistical office.

An effective dissemination programme enhances the accessibility of statistical information and contributes to the statistical production process by building relationships with data users and suppliers. In return, the statistical organization benefits from the feedback provided by users.

The Global Strategy to Improve Agricultural and Rural Statistics plans to develop a complete set of guidelines for the dissemination of agricultural statistics in 2016. Until the set is completed, this chapter presents some concepts and considerations that should be kept in mind when determining how to present and disseminate collected CoP data. Some of the concepts and recommendations presented in this section have already been addressed in this Handbook, particularly in Chapter 3. They are presented in this chapter as well to provide a consistent set of recommendations and principles on dissemination and presentation of CoP data.

6.1 PRINCIPLES TO GUIDE DISSEMINATION

When determining a dissemination plan, it is useful to note the following principles.

Release calendar:
To build trust with users and respondents, statistical organizations should publish a schedule of forthcoming releases. This notifies users, especially key users, and respondents of future releases. Trust is gained by establishing a track record of publishing survey results and meeting targeted release dates. The statistical organization can point to the release date and subsequent release to convince respondents of the value of reporting information that might be

considered an unwelcome intrusion into their affairs. Data users will be better served by planning their subsequent activities around the release dates. Additionally, fixed release dates can be used to set a target date for the survey processing cycle.

Timeliness:

A fundamental principle for dissemination is that releases are timely. Publically available timely data increases the value of that data immeasurably. Notwithstanding this, achieving a timely release can pose great challenges for statistical offices. Not all releases are equal in terms of statistical complexity and production processes. The challenges of conducting a census cannot be compared with the challenge of collecting some basic price data, for example (not to trivialize the latter). Keeping this in mind, timeliness differs for different statistical programmes. There are no firm standards for timeliness, however a "rule of thumb" adopted by many statistical organizations is to target the time required for the "end to end production" process (data collection through dissemination) as equivalent to or shorter than the frequency of the data collection. In the context of an annual cost of production survey, this means that data would be released before the next survey cycle begins. This is a challenging target, which can only be achieved if the statistical office is well-functioning.

Respondent confidentiality:

To obtain accurate data with continued cooperation from the respondents, it is incumbent on statistical organizations to preserve the confidentiality of individual data obtained from respondents. This can on occasion be very challenging as it is often dependent on the characteristics of the target population and the granularity of the data release. Releases of census population counts rarely if ever result in accidental disclosure. On the other hand, for example, releasing CoP data for hogs in a region where there is a dominant farm can reveal much about that producer. There are several methods available to deal with disclosure but none are perfect. Some of the main methods that deal with confidentiality include: reorganizing the data tables in order to make them more aggregated; releasing totals while suppressing two or more data cells within the table; deliberately adding random noise to the estimate to prevent accidental disclosure. Notwithstanding these methods, some statistical agencies have found it effective to secure data waivers from large contributors.

Equality of access:

Information produced and disseminated is only as good as the reputation of the data provider. That reputation depends on the behaviour of the institution on several fronts. Once that reputation is called into question or the public no longer has trust in the organization, then the information will not be believed and thus have little or no value. The behaviours that influence the reputation of the organization relate to real (testable) behaviours and perceived behaviours. Providing equality of access for disseminated products falls into the latter category. Failing to do so, i.e. providing an interested party with privileged access to the data, can seriously undermine the credibility of the organization in the eyes of the reporting public. However, in many cases, statistical offices segment users and provide equal access to all users within a class, but not necessarily across all classes. For example, members of the researcher class may be granted access to raw data, while the general public may only have access to summary statistics.[21]

Objectivity:

Data that are disseminated should be as objective as possible. This means that it is based on statistically sound methods and is reproducible: this would presume total transparency in matters pertaining to survey design, access to sampling frames, calculation methods and access to survey software programs. In practice, it means that the statistical authority conducts its affairs openly, adheres to sound methods and employs a quality assurance framework. Analyses that accompany the release are neutral and void of value judgements.

---

21 This is the policy adopted by USDA and Food and Agriculture Data Network of the European Union, for example.

Metadata:

The release of metadata should be made concurrently with the release of data. Giving access to metadata provides users with the requisite information on the strengths and limitations associated with the data. This allows the users to formulate a strategy on how best to incorporate the data into their own analytical framework. It also educates other stakeholders in the statistical system. The metadata should be made available in standard format, such as the Statistical Data and Metadata eXchange (SDMX), to facilitate data exchange and comparability.

Data archiving:

The value of collected data does not end when they are released. The data form an historical record arranged as a snapshot of the population surveyed. It is, therefore, the responsibility of the statistical authority to preserve this record in a way that will enable future generations of analysts and historians to access it. Each statistical office should develop and implement a data archiving strategy that preserves the data, keeps it accessible and provides future researchers and the general public with sufficient metadata to understand and interpret the archived data. Establishing such a strategy is of specific relevance in developing countries as these countries often fail to provide access to historical data so that they can be analysed as a time-series and compared with other farm-level or individual data. This greatly reduces the value of data, even if they have been collected and processed according to the highest international standards. The requirements to archive survey data in a consistent way also oblige the statistical organization to adopt common standards and concepts with respect to how the data are collected (for example, the statistical unit), when they are collected and how they are processed and disseminated (granularity, frequency, for example).

6.2 QUALITY ASSESSMENT

All official statistical outputs should be accompanied with an assessment of the quality of that data. Unlike in the 1980s, when documenting data quality was synonymous with making public known measures of sampling and non-sampling survey errors and census undercounts, it is now currently generally accepted that quality can and should be described using multiple dimensions. Today, quality is viewed within the context of a framework, which usually encompasses the following dimensions. The main dimensions of statistical quality are presented in this section. Section 3.7 of this Handbook provides more details on this topic.

Relevance:

The attribute of a data product that measures to what extent the compiled statistics meet the demands of data users, analysts and policy-makers. In that context, relevance depends on the coverage of the required topics and the use of appropriate concepts.

Accuracy:

In the context of the quality assurance framework, accuracy is the description of the extent to which the compiled statistics measure the desired or true value (or bias, in statistical terminology). Measures of accuracy include estimates of under or overcoverage. There is no definitive or single measure that adequately describes the accuracy of a data product.

Precision:

Precision measures indicate the degree of confidence placed in the estimates. 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. Those sources of errors are associated with the data collection, processing and compilation stages.

Timeliness:

Within the context of the quality assurance framework, for a data product to be useful, it must be timely. Timeliness can be measured as the distance in time units that the data are released following the reference period. With all other things being equal, the shorter the time distance, the higher the quality.

Other dimensions of a quality assurance framework are credibility, accessibility, interpretability and coherence. Section 3.7 contains a detailed description of the different components of statistical quality.

6.3 FROM DATA TO DISSEMINATION

There are many options available to get data into the hands of users. Among them are publishing hard copy publications or reports, releasing data in the form of media or press releases or setting up a communications unit to handle special data requests to release the databases from which users can design their own tables and conduct their own analyses. Each option serves different constituents and has particular strengths. No matter which vehicle is selected, it is paramount that careful consideration be given to determine the content of the dissemination vehicles. Choices will extend to include variable selection, the level of geography that is published and the design of tables and graphs and other illustration. No matter which dissemination vehicle is selected, it is essential that careful consideration be given to determine the content of the release.

To accompany the data releases, it is recommended to release the following:
• A report of the survey's methodology;
• The main findings and tabulations of the survey;
• A data analysis report;
• A data quality evaluation report;
• Specialized reports on, for example, data processing procedures, data collection and methodological studies.

Data revisions:

Data releases may be subject to revision. A revision policy should be determined in consultation with users, documented and publicized. Prior to establishing a revisions policy, it is important to consult with the main users of the statistics to identify their needs and priorities. Of course, meeting the needs of policy analysts is particularly important given the influence they collectively have on government policy, plans and priorities.

Microdata:

A statistical agency seldom has the resources or the capacity to perform all of the pertinent analysis that can be conducted with CoP data files. Increasingly, statistical agencies are creatively discovering mechanisms to allow external researchers access to microdata while at the same time preserving respondent confidentiality. Allowing external researchers access to micro data can leverage the value of the survey data enormously. This analogy written by Ernie Watkins and Wendy Boyko was taken from Global Strategy of Improve Agriculture and Rural Statistics (2015) and summarizes neatly the value of providing access to micro data to researchers.

> "Microdata are unlike other tools of the research endeavour. They provide the raw material from which information and knowledge can be created. By their nature, data allow for exploration of topics of interest to the researcher. Unlike printed tables which, like a postcard, provide a picture of one view of a larger phenomenon, data can act as a camera, allowing the researcher to manipulate the background, change the foreground and more fully investigate the object under study." (Wakins and Boyko, 2015, p.13)

International comparisons:

Cost of production data are often used for international comparisons. There are several reasons why analysts might want to compare CoP estimates. A first reason is that analysts might want to judge the competitiveness of their domestic producers with those of other countries to evaluate for example, the degree to which imports pose a significant source of competition. The flip side to this comparison is the degree to which domestic producers can compete for export markets elsewhere. A second reason to make comparisons is to evaluate the threat to domestic agriculture policy in the context of trade negotiations. In the drive towards freer trade, the cost of dismantling of tariff and non-tariff barriers can be informed by comparing CoP estimates with other treaty nations.

While comparing CoP estimates can be both informative and useful, extreme caution needs to be taken when making the comparisons. Some obvious and less obvious factors must be considered. Failure to recognize and adjust for them can make the comparisons invalid. Among the more obvious adjustments include resetting the reference period and the currency that the estimates are reported in. Less obvious are adjustments for differences in the source of the estimates: were they derived from surveys or panels? Did they use probability sampling? Are they representative of the countries being compared?

There are other considerations that include whether the commodity in question is defined to be the same in terms of quality and any other characteristic that affect price. It is also important to note that the unit of measure is the same and is sensible. For example, using a cost per unit output for crops might not be the best measure as yields for crops might not be from a "normal year". It might be better to use cost per land area.

Importantly, the analyst must ensure the following: the comparisons are as equivalent as possible; the expenses and revenues are alike and are exhaustive to the same degree; and the estimation methods are similar and if not, that appropriate adjustments are made. Differences in methods are most likely to be for those expenses that are more difficult to measure and while not limited to, are common when estimating for opportunity costs (land, labour and capital). The analyst must also keep in mind and adjust if necessary, the impacts of government programme payments (output and input) on costs and returns.

6.4 DESIGNING TABLES

A multitude of tables can be produced from CoP surveys. Tables 6.1 and 6.2 are but two examples.

To add to the value of the data release and in areas in which quality is sufficient, it is advisable to present the data according to relevant groupings. A non-exhaustive list would include data classified by size (land, sales values or capital), degree of product specialization, region and technology. This process adds to the analytical power and interpretability of the survey result.

When designing tables, it is important to keep in mind that the interpretability and usability of published indicators are bound by:
• The quality (accuracy, precision) of the underlying data;
• The representativeness of the dataset with respect to such characteristics as geographical areas, farm and activity types:
• The published indicators should be compiled for sufficiently homogenous groups of observations, such as farm type and region;
• Possible biases (known factors leading to consistent over or underestimation) should be identified.

Below are examples of topics which can be informed by statistical tables on CoP:

Farmer demographics:

In the context of CoP, sample tables may indicate data and tabulations pertaining to the farmer including gender, age (average and distributions), education of the operator, years of farming experience and main and secondary occupations. All of these tables can be distributed by region or agro-ecological zone if the data permit that level of detail.

Production practices and environmental indicators:

Tables on production practices may be useful in presenting data on yields, ploughing, cultivating and harvesting methods, production on irrigated or non-irrigated land, hours of labour used, yields using purchased or owner supplied seeds.

Most environmental indicators can be defined as a subset of production practices and relate variables of interest with base variables. Examples include energy use per ha (fuel & lubricants use + electricity use)/land area, organic and inorganic fertilizers applied/land area, pesticide and herbicide use/land area. The indicators can be combined with auxiliary data to make them easier to interpret. One such example is the measure of atmospheric emissions associated with fuel use, which combines fuel use with an emissions factor. A more detailed list of analytical indicators is provided in section 3.4.

Farm economics and financials:

One of the core uses of CoP surveys is to illustrate the relationship between production values and input costs. In that regard, dissemination tables can be designed to report on the value of production for the product in question, the farm variable costs whether purchased or owner-supplied, capital service costs and opportunity costs.

The amount of detail can vary and is limited by the amount of detail the survey can legitimately support. Common disaggregates include breaking down agricultural expenses into variable costs (seed, purchased or owner supplied, fertilizer by type and nutrient, herbicides, pesticides, custom work, fuel, repairs, paid and exchanged labour and interest expenses on purchased inputs); general overhead costs (office and office supplies, heating fuel) and opportunity costs (land and labour).

Farm financial data can also be displayed in the form of performance or efficiency ratios. Commonly disseminated ratios include gross and net margins, cash flow, cost/area, cost/unit of production and the breakeven price per unit of output.

TABLE 6.1
United States corn production costs and returns per planted acre, excluding government payments in USD, 2013-2014

Item	United States	
	2013 (USD)	**2014 (USD)**
Gross value of production		
• Primary product: Corn grain	719.16	601.80
• Secondary product: corn silage	1.35	1.38
• Total, gross value of production	720.51	603.18
Operating costs:		
• Seed	97.59	101.04
• Fertilizer[a]	153.33	149.23
• Chemicals	28.57	29.20
• Custom operations[b]	17.77	18.24
• Fuel, lube, and electricity	32.27	32.80
• Repairs	25.79	26.17
• Purchased irrigation water	0.12	0.12
• Interest on operating capital	0.16	0.12
• Total, operating costs	355.60	356.92
Allocated overhead:		
• Hired labour	3.12	3.16
• Opportunity cost of unpaid labour	24.40	24.75
• Capital recovery of machinery and equipment	96.86	100.15
• Opportunity cost of land (rental rate)	167.74	175.60
• Taxes and insurance	9.19	9.34
• General farm overhead	19.54	19.88
• Total, allocated overhead	320.85	332.88
Total, costs listed	676.45	689.80
Value of production less total costs listed	44.06	-86.62
Value of production less operating costs	364.91	246.26

Source: USDA, ERS using Agricultural Resource Management Survey data and other sources, 2014.
Note: Developed from survey base year, 2010.
[a]Cost of commercial fertilizers, soil conditioners, and manure.
[b]Cost of custom operations, technical services, and commercial drying.

TABLE 6.2
Average production costs and returns of corn in the Philippines (January-June 2013)

Production	kg	339.26	3,524
Area harvested	ha	0.74	
Number of farms		11	

	Physical unit	**Physical unit/ha**	**Pesos/ha**
CASH COSTS			**1 555**
• Seeds	kg	0.61	49
• Inorganic fertilizers: Solid	kg	0.31	9
• Hired labour	manday	6.04	979
• Land tax			43
• Rentals: Machine, Animals, Tools and Equipment			61
• Sacks and tying materials / needle			76
• Food expense			135
• Repairs			202
NON-CASH COSTS			**1 439**
• Seeds	kg	8.40	494
• Harvesters' share	kg	45.09	475
• Landowner's share	kg	35.39	363
• Rentals: Machine, Animals, Tools and Equipment	kg	10.74	107
IMPUTED COSTS			**3 233**
• Seeds	kg	0.61	37
• Operator labour	manday	10.35	1,511
• Family labour	manday	10.18	1,424
• Depreciation			79
• Interest on operating capital			59
• Rental value of owned land			123
TOTAL COSTS			**6 228**
GROSS RETURNS			3,524
RETURNS ABOVE CASH COSTS			1,968
RETURNS ABOVE CASH AND NON CASH COSTS			529
NET RETURNS			(2,704)
NET PROFIT-COST RATIO			(0.43)
COST PER KILOGRAM			**18.36**
FARMGATE PRICE PER KILOGRAM			**10.39**

Source: Ministry of Agriculture of Philippines, 2014.

7

Conclusion

The objective of this Handbook was to present and discuss the best practices with respect to the collection, compilation and dissemination of statistics on CoP in agriculture, with a specific emphasis on developing countries. This publication is the result of a collective effort led by the Statistics Division of FAO, under the aegis of the Global Strategy to improve agricultural and rural statistics and the technical and theoretical guidance of several experts, many of whom are from the developing world. The structure and content of this Handbook were driven by the needs, priorities and concerns of developing countries, which were involved in all stages of producing it from the inception.

A holistic approach was used in preparing this Handbook, starting with the user needs and ending with guidelines on how to best present and disseminate the data and statistical outputs. In that sense, it goes beyond the scope of agricultural cost of production statistics per se, with many sections devoted to topics that are of relevance to virtually any statistical operation. In view of implementing its recommendations, the reader is therefore strongly advised to refer to the literature references mentioned throughout the document and especially to other handbooks and reports produced in the context of the Global Strategy. Those references address in greater detail general statistical topics, such as sampling designs, sampling frames or data and microdata dissemination strategies.

As any research product, this Handbook inevitably has its shortcomings, some of which result from the approach adopted (more hands-on than theory-based) and the compromises that had to be made between exhaustivity, scientific soundness and applicability in a developing country context. Nevertheless, it is hoped that this publication has addressed the concerns of developing countries regarding the lack of international guidelines on the provision of sound statistical information on production costs and profitability in agriculture. More generally, it is also hoped that this Handbook will contribute in the medium-term to improving the quality, availability and international comparability of the statistical information on agricultural costs of production.

References

AAEA Task Force on Commodity Costs and Returns. (2000). *Commodity Costs and Returns Estimation Handbook*. United States Department of Agriculture: Ames, Iowa, USA.

Bangladesh, Bureau of Statistics. (2010). *Report on the Cost of Production of Wheat Crop 2008-2009*. Bangladesh: Bureau of Statistics, Ministry of Planning.

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

Burke, William J., Munguzwe Hichaambwa, Dingiswayo Banda and T.S. Jaynel. (2011). The cost of maize production by smallholder farmers in Zambia, Working Paper No 50, Food Security Research Project. Lusaka: Government of Zambia.

Companhia Nacional de Abastecimento (Conab). (2010). *Custos de Produçao Agricola: A metodologia da Conab*. Brasil: Companhia Nacional de Abastecimento.

Desbois Dominique. (2006). *Méthodologie d'estimation des coûts de production agricole : comparaison de deux méthodes sur la base du RICA*. Revue MODULAD, num. 35

El-Osta Hisham and Ahearn Mary. (1996). *Estimating the Opportunity Cost of Unpaid Farm Labor for US Farm Operators*. USDA ERS, Techn. Bull. 1848, March.

Instituto Nazionale di Economia Agraria (INEA). (2013). *The use of RICA to estimate the cost of production in agriculture: application of econometric and mathematical programming methodologies*. Italy: Instituto Nazionale di Economia Agraria (INEA).

Food and Agriculture Organization of the United Nations (FAO). (1989). *Sampling Methods for Agricultural Surveys*. FAO Statistical Development Series 3. Rome.

_____ (2005). *A system of integrated agricultural censuses and surveys, Volume 1: World Programme for the Census of Agriculture 2010*, FAO Statistical Development Series. Rome.

_____(2010). *A system of integrated agricultural censuses and surveys*. *Volume 1: World Programme for the Census of Agriculture 2010*, FAO Statistical Development Series. Rome.

Foreman, L. (2012). *Characteristics and Production Costs of U.S. Cotton Farms*. USDA/ERS. Bulletin Number 104. Available at: http://www.ers.usda.gov/media/972207/eib104.pdf. Accessed 23 January 2014.

Global Strategy to Improve Agricultural and Rural Statistics (GSRAS) (2014), *Technical report on the integrated survey framework, Technical Report Series GO-02-2014*. Rome.

_____(2012). *Cost of Production (CoP) Statistics: Synthesis of the Responses to the Questionnaire on Country Practices*. FAO: Rome (internal document available upon request).

_____(2014). *Technical report on the Integrated Survey Framework*. Global Strategy to Improve Agricultural and Rural Statistics, Technical Report Series GO-02-2014, June.

_____(forthcoming). *Handbook on Master Sampling Frame*. Global Strategy to Improve Agricultural and Rural Statistics, Draft Technical Report Series GO-XX-2015.

_____(2014). *Providing Access to Agriculture Microdata: A Guide*. Available from http://gsars.org/providing-access-to-agriculture-microdata-a-guide/. Accessed December 2015.

McBride, W., and Greene, C. (2009). *The Profitability of Organic Soybean Production*, Renewable Agriculture and Food Systems, 24, no. 4 (December): 276-284.

McBride, W., and Greene, C. (2009a). *Costs of Organic Milk Production on U.S. Dairy Farms*. Review of Agricultural Economics, 31, no. 4 (Winter 2009): 793-813.

McBride, W. and Key, N. (2013). *U.S. Hog Production From 1992 to 2009: Technology, Restructuring, and Productivity Growth*. Economic Research Report No. (ERR-158) 48 pp.

Mrema, Geoffry.C., Baker, D., and Kahan D. (2008). *Agricultural mechanization in sub-Saharan Africa: time for a new look*. Agricultural Management, Marketing and Finance Occasional Paper. FAO: Rome.

Peeters, L., and Surry, Y. (2002). *Farm Cost Allocation Based on the Maximum Entropy Methodology: The Case of Saskatchewan Crop Farms*. Agriculture and Agri-Food. Ottawa, Canada.

Philippines Statistics Authority (2011). *Costs and Returns of Palay Production*. Philippines: Bureau of Agricultural Statistics. Available at: http://agstat.psa.gov.ph/?id=460&ids=download_now&p=1&dami=10&srt=dateadd. Accessed 6 December 2015.

_____(2014). *Cost and Returns of Corn Production*. Philippines Bureau of Agricultural Statistics. Available at: http://agstat.psa.gov.ph/?id=812&ids=download_now&p=1&dami=10&srt=dateadd.

_____(2015). 2013 *Costs and Returns of Palay Production*. Available at: http://agstat.psa.gov.ph/?id=818&ids=download_now&p=1&dami=10&srt=dateadd. Accessed 3 January 2016.

Ronzon, T., Ciaian. P., l, Gomez, S., Delincé P., and Delincé J. (2014). *Literature review on cost of production methodologies*. Global Strategy for Improving Agricultural and Rural Statistic. Technical Report Series GO-04-2014.

Sen, Abhijit and M.S. Bhatia. (2004). *Cost of Cultivation and Farm Income," in State of the Indian Farmer, Volume 14*. India Department of Agriculture and Cooperation: New Delhi.

Short, Sara D. (2004). *Characteristics and Production Costs of US Dairy Operations*. Statistical Bulleting Number 974-6, February, Electronic report from the Economic Research Services. USDA. Available at: www.ers.usda.gov/publications/sb-statistical-bulletin/sb974-6.aspx. Accessed on 6 December 2015.

United Nations, Department, Department of Economic Statistics. (2013). *Guidelines on Integrated Economic Statistics*. United Nations Publication Sales No. E.12.XVII.7.

Walker, Rodney L., and Darrell D. Kletke. (1972). *The Application and Use of the Oklahoma State University Crop and Livestock Budget Generator*. Oklahoma State Agricultural Experiment Station Report P-663.

Watts, Myles J., and Glenn A. Helmers. (1981). Machinery costs and Inflation. Western Journal of Agricultural Economics 6:129-145.

Annexes

1. COUNTRY-LEVEL DATA COLLECTION QUESTIONNAIRES

United States

<u>Comments</u>: questionnaires are accompanied by booklets and manuals for interviewers and respondents. The 2012 soybean questionnaire was 35 pages. It included sections on farm environmental practices, such as pest management practices, but it had no section on buildings, such as warehouses.

Link to the online questionnaires and related information: www.ers.usda.gov\\data-products\\arms-farm-financial-and-crop-production-practices.

South Africa

<u>Comments</u>: 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: www.statssa.gov.za/agriculture

Niger

<u>Comments</u>: 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:

http://siteresources.worldbank.org/INTSURAGRI/Resources/7420178-1294154308081/ECVMA_Quest_AGR_P1_V10_eng.pdf

Nigeria

<u>Comments</u>: a questionnaire on agricultural post-planting costs, part of the general household survey programme; 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

2. SAMPLE DESIGNS

Sample surveys consist of collecting data from a subset of the targeted population (sample). One desirable property of most of the sample surveys is its 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 subcategories. Some of the common 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 percent (the sample size represents 10 percent of the population), each unit will have a 10 percent 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 represents 10 units of the population).

Probability Proportional to Size sampling: Referred to as PPSS, this method is also known as Poisson sampling. It takes advantage of the information that exists on the size variable of each of the statistical units, such as number of hectares of land, turnover, revenues and output. 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). 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 or, its geographical location, among others. 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 subsample. 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 enables the size of the sample to be reduced. 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, such as farm size, for all the units of the population.

Multistage cluster sampling: In cluster sampling, the population is first partitioned into clusters and subclusters, representing, for example, 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 10 km per 10 km 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, depending on the availability and use of additional information to increase the efficiency of the sample, that is the 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 in 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, a 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 that 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; or their interest in the study, among other conditions. 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 of a number of reasons, including, among others, individuals may be more motivated to provide the information required or they may have a closer relationship with the surveyor. This makes them useful for conducting pilot studies.

3. SAMPLING VARIANCES FOR SIMPLE AND COMPLEX SAMPLE DESIGNS

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, the formula to compute sampling variances for $\underline{Y}_{est}$ in the case of simple sampling designs is given. For more complex designs or estimators (ratio estimator, generalized regression estimator, etc.), refer to (FAO 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 $\underline{Y}_{est}$ 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 $\underline{Y}$. Under the assumption that $\underline{Y}$ follows a normal distribution, its 95 percent confidence interval is given by:

$$IC_{95\%}(\underline{Y}) = \underline{Y}_{est} \mp 1.96.s(\underline{Y}_{est})$$

Stratified sampling: Consider a partition of the population U in H distinct groups or strata, such as classes of farm sizes, each composed of N_h statistical units.

<u>Case 1</u>: Within each stratum, each statistical unit is selected using simple random sampling. Each subsample, S_h, is of size n_h, with size $\omega_h = \frac{N_h}{N}$, used for weighting. The estimate of $\underline{Y}$ is:

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

The estimated variance of $\underline{Y}_{est}$ is the weighted average of variances within each subsamples:

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

Where $s^2(Y_h)$ is the variance of the variable of interest in each of the S_h (intra-strata variance).

<u>Case 2</u> : The size of each stratum is determined by proportional allocation, where the sample sizes, n_h are determined by applying a uniform sampling rate in each stratum: $f = \dfrac{n_h}{N_h} = \dfrac{n}{N}$. This selection procedure ensures that each subgroup is represented in the sample in proportion to its importance in the overall population $\dfrac{n_h}{n} = \dfrac{N_h}{N}$. The inclusion probabilities of each statistical unit in S is simply $\dfrac{1}{N}$, as in the case of simple random sampling and

$\overline{Y}_{est} = \dfrac{1}{n} \sum\limits_{i \in S} Y_i$. The variance of $\underline{Y}_{est}$ is the weighted average of the intrastrata variances:

$$s^2(\overline{Y}_{est}) = \frac{1-f}{n^2} \sum_{h \in H} n_h s^2(Y_h)$$

Multistage sampling: Each strata, h, is further partitioned into a set A_h of substrata or primary sampling units, $A_h=(a_{1,h},\ldots,a_{j,h},\ldots,a_{J,h})$, each composed of $N_{a_{j,h}}$ statistical units or final sampling units (e.g. farm holdings). The multistage sampling consists of randomly selecting a set a_h of primary sampling units in each stratum. Each resulting sample S_h is composed of $N_{a_h} = \sum\limits_{j \in S_h} N_{a_{j,i}}$ statistical units. In a second stage, a random sample of statistical units is selected within each S_h. Each resulting sample, $S(S_h)$, of size $N_{a_{j,h}}$, is composed of $n_{a_h} = \sum\limits_{j \in S_h} n_{a_{j,h}}$ individual units to be surveyed. The average of the variable of interest is estimated by: $\overline{Y}_{est} = \dfrac{\sum_{h \in H} \sum_{i \in S(S_h)} Y_i}{\sum_{h \in H} n_{a_h}}$. Both

numerator and denominator are random variables because of random selection of the substrata and their unequal sizes. This creates methodological problems, especially in relation to the computation of the variance, which is given by the following formula:

$$s^2(\overline{Y}_{est}) = \frac{1-f}{n} \left(\sum_{h \in H} dY_h{}^2 + r^2 \sum_{h \in H} dn_{ah}{}^2 - 2r \sum_{h \in H} dY_h dn_{ah} \right)$$

Where $Y_h = \sum\limits_{i \in S(S_h)} Y_i$, $dY_h{}^2 = \dfrac{|a_h| \sum_{j \in S_h} Y_{j,h}{}^2 - Y_h{}^2}{|a_h| - 1}$,

$Y_{j,h} = \sum\limits_{i \in S(S_h)} Y_{i,j,h}$, $dn_{ah}{}^2 = \dfrac{|a_h| \sum_{j \in S_h} n_{a_{j,h}}{}^2 - n_{a_h}{}^2}{|a_h| - 1}$ and $dY_h dn_{ah} = \dfrac{|a_h| \sum_{j \in S_h} Y_{j,h} n_{a_{j,h}} - Y_h n_{a_h}}{|a_h| - 1}$

4. SYNTHESIS OF THE RESPONSES TO THE 2012 SURVEY ON COUNTRY PRACTICES

In the framework of the Handbook on Agriculture Cost of Production Statistics developed by FAO and following the recommendations of the twenty-first African Commission on Agricultural Statistics , which was held in 2009, FAO has carried out a global survey on agricultural CoP practices in order to compile information about countries best practices for CoP estimate, data dissemination, users and uses. The global survey was conducted between March and April 2012. The questionnaires were sent to 167 FAO member countries out of which 80 countries responded with a complete filled questionnaire. The objectives of this survey, its methodology and main findings are presented in this annex.

Objectives
- Provide an estimate of the share of FAO member countries producing CoP statistics;
- Provide an overview of the main methodological choices and orientations in producing CoP statistics, including the identification of potential methodological and data gaps;
- Provide an overview of the reasons explaining the absence or lack of CoP statistics in countries.

Methodology
An Excel-based questionnaire was conceived, composed of the following sections:
- Section 1 filters the countries according to the existence (past or present) of CoP statistics;
- Section 2 provides the opportunity for countries that do not produce such statistics to indicate the main reasons underpinning this choice;
- Section 3 deals with the organization and overall planning of the process of data collection;
- Section 4 requests countries to provide basic information on the design of the surveys and/or other data collection sources;
- Section 5 aims to identify country practices regarding data reporting and dissemination;
- Section 6, finally, asks countries to identify the main users and uses of CoP statistics.

Main findings
1. Availability of CoP statistics and data sources
- Approximately 75 percent of the countries that responded to the survey have experience in compiling CoP statistics and close to 60 percent currently collect this type of information;
- To collect data on cost of production, countries tend to use multiple data collection methods, especially combining stand-alone surveys with non-survey sources.

2. Survey design
- Samples of farms are generally selected through the use of complex designs, such as stratification schemes.
- Surveys tend to cover a broad base of variable cost items, including the main ones, such as fertilizers, crop protection, feed and seed. Home-grown inputs are less covered.
- Information on fixed costs gathered through surveys is less abundant than for variable costs. Land-related costs are one of the least available cost items.
- Cost of production statistics for crops are more often available than for livestock activities.
- Roughly 20-30 percent of the countries only produce aggregated statistics, with no breakdown according to the type of activity.

3. Data dissemination and uses
- Online reports and databases constitute the main dissemination method. There is, however, still room for improvement regarding the dissemination of databases on CoP statistics, with roughly half of the countries that do not use this type of support.
- Statistics on CoP are often used in the construction of national accounts for the agricultural sector. However, the use for policy advisory work and agricultural policy design has also been highlighted.

Glossary

Average costs
Total costs (variable and fixed) per unit of output produced, such as per ton of wheat and per thousands of litres of milk.

Cash costs
Inputs purchased by the farmer by direct cash payment, such as fertilizer, fuel and pesticides.

Direct costs
Costs that can be unequivocally attributed to the production of a given commodity, such as fertilizers.

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 (or agricultural) holding
An 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. The 2010 World Census of Agriculture further defines an agricultural holding as an "economic unit of agricultural production under single management comprising all livestock kept and all land used wholly or partly for agricultural production purposes, without regard to title, legal form, or size. Single management may be exercised by an individual or household, jointly by two or more individuals or households, by a clan or tribe, or by a juridical person such as a corporation, cooperative or government agency. The holding's land may consist of one or more parcels, located in one or more separate areas or in one or more territorial or administrative divisions, providing the parcels share the same production means, such as labour, farm buildings, machinery or draught animals" (http://www.fao.org/docrep/004/x2919s/x2919s05.htm).

Fixed costs
Costs that can be considered as independent from the quantities produced, such as 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, for instance, additional harvesting machines must be bought when the crop area rises above a certain size.

Indirect costs
Cost shared by different commodity production processes or farm enterprises and which cannot be attributed unequivocally to each commodity.

Intercropping
Agricultural practice consisting in the growing of two or more crops in proximity. Mixed intercropping is the practice of growing different crops on the same piece of land, which is equivalent to mixed cropping; row intercropping means that different crops are arranged in different rows; relay intercropping 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 of growing two or more crops simultaneously on the same piece of land. See also intercropping.

Multiyear enterprise

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

Non-cash costs

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

Opportunity costs

Implicit benefit or revenue foregone due to an investment decision or input allocation. The opportunity costs reside 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; or 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 a farm, such as technical coefficients and farm profitability measures. This method is based on the construction of a 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, among others, a panels of farmers, farm extension, workers, local experts and, researchers, 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, such s list of households determined from censuses, or companies identified by their fiscal number, though alternatives include area frames that may also be used in agriculture.

Survey sampling

Process of selection of a subset 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 selecting 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 that vary according to the quantities produced. This can be applicable to such things as fertilizers, seasonal labour and, fuel.