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# Literature Review on
# **Cost of Production Methodologies**

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# Literature review on Cost of Production Methodologies

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# Abstract

This working paper provides a review of the literature on methodologies applied for data collection and processing of cost of production (CoP) in agriculture in developed and developing countries. The report focuses on three main aspects of CoP methodologies: CoP survey design, CoP calculation and CoP international comparisons. For each of these topics, a description of existing practises is given alongside to an assessment of their main advantages and drawbacks. Based on the identified "good practices", as well as the expert judgment reported in the literature, the report formulates recommendations regarding each relevant methodological topic to be considered when developing and conducting CoP collection and calculation.

Member countries of the Food and Agriculture Organization (FAO) of the United Nations requested methodological guidance in developing Agricultural Cost of Production statistical programs. To address this request, the Global Strategy to Improve Agricultural and Rural Statistics funded work on a Cost of Production Handbook, targeted at developing countries. This literature review was prepared by the Joint Research Centre of the European Commission to provide background information that could inform development of the Handbook.

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**Key words:** agricultural costs of production statistics, cost allocation, survey design

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# 1

# Introduction

The structure and level of cost of production (CoP) have major implications for the competitiveness of agriculture and the income level of farmers. Production costs not only shape the development of farming systems, but also affect their sustainability and determine overall food production potential. CoP analysis has become a powerful tool to understand and compare the conditions of competitiveness of different farming systems. As such, CoP analyses have gained renewed attention from international organisations that have recently concentrated their efforts to better understand the functioning and the methodologies applied by national statistic services worldwide.

In developed countries, CoP data collection systems have been implemented for two decades or more (e.g. 1965 for the European Farm Accountancy Data Network, 1996 for the Agricultural Resource Management Survey in the USA). Since then they have evolved and attained a quite stable and well defined methodology. They often rely on substantial financial resources and skilled human resources (especially in statistics), which allow the running of sophisticated methodologies, described in detail in public reports and handbooks (AAEA 2000; Cesaro *et al*. 2008; Cesaro and Marongiu 2013; FADN 2010).

In developing countries, such as Sub-Saharan African and Asian countries, there is a large heterogeneity of situations regarding the stage of implementation of CoP data collection systems. When they exist, CoP survey methodologies can be either under test in countries with little or sporadic experience in this field, or can be well-established in countries benefiting from a longer timeframe of CoP survey implementation. In emerging countries, such as in Argentina, Brazil, India, the Philippines and Ukraine, CoP methodologies are relatively well established. However, in the vast majority of Sub-Saharan Africa and Asian countries there is no evidence of a national system for CoP data collection. Instead, the field is left to sporadic academic studies1 or, in

[1] See for instance Ismail *et al*. (2003), Staal *et al*. (2003), Sarker and Ghosh (2008), Burke *et al*. 2011, and Wambugu *et al*. (2011).

some cases, CoP is roughly estimated from agricultural census data or other agriculture-related studies. According to surveys led in 2010 in the framework of the "Global Strategy to Improve Agricultural and Rural Statistics," "35 percent of [African] countries had conducted a cost of production survey, whereas about 65 percent had an operational market information system in place" (ADBG-AUC-FAO 2011).

The availability of good quality data on CoP is a key requirement for conducting comparative analysis useful for policy decision, and for scientific output and/or for the decisions of agricultural market agents. In view of this, this report aims to provide a review of methodologies on CoP approaches as applied in developed countries (Australia, Canada, EU, France New Zealand, USA), emerging countries (Argentina, Brazil, Ukraine), Sub-Saharan African and Asian countries (India, the Philippines, the Republic of Mauritius, Sri Lanka and Zambia) and by Global Networks (agri-benchmark, IFCN). The information from these countries is supplemented by findings reported in the scientific and policy literature on CoP methodology and application. More specifically, the report aims to summarize the methodologies and approaches for data collection and processing and their appropriateness as well as to provide recommendations.

The selection of countries has been motivated by the diversity of approaches they illustrate, ranging from: a very well established CoP survey in developed and developing countries (e.g. US, EU, Brazil, India) to a one-shot survey in Mauritius; from stand-alone surveys to integrated ones; from holding-wise to plot-wise data collection; from representative farm to sample of farms survey; and so forth. Attention has also been paid to present case studies from all main world regions (Asia, Sub-Saharan Africa, Australia, Europe, North America, South America) as well as to present methodologies which are harmonised across countries and thus deliver international comparable CoP data (agri-benchmark, IFCN).

The literature review is organized in three main parts related to CoP survey design, CoP calculation, and CoP international comparisons. For each of these topics, a description of existing practises is given along with an assessment of their main advantages and drawbacks. The identification of "good practices" among our country cases, as well as the expert judgment reported in the literature, lead to the formulation of final recommendations regarding each relevant methodological topic to be considered when developing and conducting CoP calculations.

# 2

# How to collect, process and disseminate CoP

## 2.1 Which instrument: representative farms vs. integrated surveys vs. stand – alone surveys?

It is striking that there is not a uniform way to calculate CoP estimates. According to their needs and budget, countries have opted for soft to comprehensive methods (see Table 1). Some countries reconstitute CoP estimates through the consultation of extension services' staff, agricultural experts and public and private data. While not permitting national inferences, this strategy allows for strong flexibility at minimal cost: according to its needs, the government can ask for the CoP estimate of a particular zone or system of production, and estimations can be repeated after a particular economic or policy event or to inform on the impacts of the introduction of a new technology.

A number of countries and, in particular, international networks, including agri benchmark (crop sector) and IFCN (dairy sector), rely on the *"representative" farm approach* to estimate CoP. Under this approach, CoP are collected for hypothetical farm types representing the major production systems (in terms of size, specialization, etc.) in a given region or country. This requires the implementation and maintenance of an ad hoc network of experts who are able to elaborate and update farm types according to a uniform method. This method generally does not allow for national inferences, but it does provide large technical details on the "typical" farm functioning and the complete cost components, resulting in an interesting cost-effective approach. Experts can also add to their results some contextual qualitative information. Moreover, by relying on a panel of experts and farmers' judgment as well as on modeling capacities, this approach avoids the sensitive issues of confidentiality and non-response.

*Examples of countries relying on "representative farms" for CoP estimation:*

- National Food Supply Company (CONAB) in Brazil compiles information on agricultural CoP with the purpose of identifying differences in competitiveness between regions and technologies. The calculation method adopted by CONAB aims to account for all costs items incurred by producers from the production initiation stage to product commercialization (Teixeira 2011; CONAB 2010).
- The agri benchmark and the IFCN are the main data sources available for international comparison of production costs. These approaches are based on networks of experts, advisors, panel of farmers and statisticians located in different parts of the world who collect and process data locally, and are coordinated by a central organization located in Germany (Isermeyer 2012).
- The RENAPRI network collects CoP data for selected countries from East and Southern Africa using the agri benchmark approach, with the aim to use them for inter-regional analysis of agricultural competitiveness and food trade (Gitau 2013; Jayne et al. 2013).
- In the Ukraine, CoP for representative farms is created within the AgriEfficiency project and the agri benchmark project (embedded in the worldwide agri benchmark consortium), operated by the Ukrainian Agribusiness Club (UCAB) (Isermeyer 2012, Slaston (2011).

A second approach, the integrated survey, consists of using existing survey efforts, whether by combining sources from on-going survey programs (Ethiopia, Mali, EU and USA) or by adding specific questions into an integrated survey (Zambia). This option takes advantage of the infrastructure and human resources already in place to perform the on-going program/integrated survey, and benefits from the knowledge accumulated by its implementers. However, the integrated survey is not flexible in terms of geographical coverage and the target sampled. It also requires from the national statistic services a high degree of database management and data organization, but provides a reasonable cost-effectiveness in terms of the marginal cost of obtaining CoP estimates.

*Examples of countries relying on an "integrated survey" for CoP estimation:*

- The EU collects CoP data across all its 27 member states through the Farm Accountancy Data Network (FADN). The FADN was launched in 1965 for the purpose of evaluating the income of agricultural holdings, development of agricultural holdings, and evaluation of the impacts of the Common Agricultural Policy (FADN 2010).
- In the United States CoP data have been gathered since 1996 as part of the annual Agricultural Resource Management Survey (ARMS). Data in prior years were collected as part of the annual Farm Costs and Returns Survey (FCRS) (USDA-ERS 2012a, 2012b).
- In Australia the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has collected CoP production through farm surveys for the last 33 years (Isermeyer 2012).
- CoP estimates in Zambia can be drawn from two integrated surveys: the Crop Forecasting Survey (CFS) and the Post-Harvest Survey (PHS) (Burke et al. 2011). These surveys have been jointly conducted since the 1990's by the Ministry of Agriculture and Cooperatives (MACO-Agriculture Statistics and Early Warning Section) and the Central Statistical Office (CSO). CFS is used by the government to calculate the National Food Balance Sheets (NFBS) and as an instrument for information-based policy support in the design of national food security and agricultural development policies (MACO/CSO 2009; MACO/CSO 2011).
- The Integrated Surveys on Agriculture (LSMS-ISA) project was established by the Bill and Melinda Gates Foundation and implemented by the Living Standards Measurement Study (LSMS) within the Development Research Group at the World Bank. It implements systems of multi-topic, nationally representative panel household surveys in seven partner countries in Sub-Saharan Africa. The survey collects data on household, agriculture, and community characteristics. Within the agricultural section of the survey some selected data on agricultural inputs are collected, such as family and hired labour, seeds, fertilizer and pesticides/herbicides applications (WB 2013).

Lastly, an additional approach is to implement a *stand-alone survey* whose design can theoretically perfectly fit with the government needs in terms of geographical and commodity coverage, farm targeting and data collection methods. Nevertheless, this option is costly and, in most cases, has to be counterbalanced by a low frequency as well as other compromises in terms of sampling, commodity coverage or human resources allocated. In addition, stand-alone surveys tend to amplify farmers' response burden when multiplying the number of interviews.

*Examples of countries relying on a "stand-alone survey" for CoP estimation:*

- In Canada most CoP data is collected by various agencies for their specific purposes, and is conducted at the regional (province) level or national level.
- In the Philippines, the Costs and Returns Surveys (CRS) have been conducted since 1992 by the Bureau of Agricultural Statistics (BAS). They are mainly aimed at supporting the agricultural Research and Development Program as well as the formulation of development plans and programs. CRS are part of the CountrySTAT program from FAO.
- In India, since the 1970's, the "Comprehensive Scheme for Study of Cost of Cultivation of Principal Crops in India", operated by the DESMOA (Directorate of Economics and Statistics in the Ministry of Agriculture), provides a common framework to the different Indian States (CSO 2005, DESMOA website[2]). Cost of Cultivation of Principal Crops (CCPC) surveys directly serve the establishment of minimum support prices (Mehta 2011).
- In Sri Lanka, the Ministry of Agriculture is in charge of two kinds of CoP surveys following very distinct methodologies: (i) A survey on Cost of Production of Major Plantation Crops, covering Tea, Rubber and Coconut produced by large estates since the 1980's: and (ii) a survey on Cost of Cultivation of Seasonal Crops, covering food crops since the late 1980's (FAO/APCAS 2008; Sri Lanka-Department of Census and Statistics 2009).
- The Republic of Mauritius ran its first CoP survey in 2005. Called the Agricultural Cost of Production Survey (ACOPS), it was operated by the Central Statistics Office (CSO) with technical assistance from FAO. The APOCS pursued three main objectives, among others: (i) to fill gaps in agricultural statistics on the cost of production and prices and to

[2] http://eands.dacnet.nic.in/Cost_of_Cultivation.htm

update indicators used in national accounts; (ii) to provide inputs for the formulation of agricultural price policies; and (iii) to enrich the construction of indicators for monitoring the environment, food security and to improve various accounts related to agriculture and food balance sheet (Ministry of Finance and Economic Development-CSO (2008).

***Recommendations***

Despite its costliness and the fact that several countries do not implement any stand-alone CoP survey, when interviewed, the FAO "friends of the chair recommendations for cost of production surveys" clearly considered the "stand-alone survey" approach as the best practice, for the many reasons aforementioned (Lys 2012).

Nevertheless, integrated surveys have demonstrated their efficiency in the USA (ARMS) and Europe (FADN). Conducted on very large samples and relying on questionnaires that address a large range of agricultural holding-related issues, they enlarge the scope of possible analyses. Their databases have been left to academics' disposal and lead to a wide corpus of evidence-based studies. As such, they have become real instruments for policy support.

**Table 1: Patterns of survey design adopted in selected countries**

| | EU | USA | Brazil | agri benchmark/ IFCN | The Philippines | India | Sri Lanka | Mauritius | Zambia |
|---|---|---|---|---|---|---|---|---|---|
| **Purpose** | Policy support+ Income and business analysis of farms | Policy support + Performance analysis of the agricultural sector | Policy support + Performance analysis | Analysis | Policy support + agricultural R&D programs | Formulation of Minimum Support Prices | Policy support | Fill gaps in agricultural statistics + policy support | National Food Balance Sheets + Performance indicators |
| **Geographic coverage** | All EU Member States ➔**EU and national average inferences** | USA ➔ **National averages** | Brazil | Selected countries from Europe, Asia, Australia, Africa, N. and S. America | According to geography of production ➔ **National averages** | 19 States of 28 ➔ **State averages** | 100% holdings for export crops National coverage for food crops ➔ **National averages** | National coverage, according to agro-climatic zones ➔ **National averages** | All Zambian districts ➔ **No release of CoP** |
| **Number of households interviewed** | ≈ 80,000 farms | Not specified | Representative farms | Representative farms | Not specified | 4,500 for paddy crop vs 300 for coconut | ≈1,000 households for paddy (1988) | 60-100 household for each food crop | 100% large-scale holdings >10,000 S&M holdings for maize |
| **Number of enumerators** | Not specified | Not specified | Panel of experts and farmers | Panel of experts and farmers | Not specified | Not specified | Not specified | 18 | 340 for small and medium holdings 40 for large-scale holdings |
| **Frequency** | Annually | 4-8 years | Annually | Annually | ≈ 5 years with annual updates | Annually (except Tobacco) | Annually for export crops, not specified for food crops | One-shot survey in 2005 | Annual CFS but no CoP calculation |
| **Number of visits** | Not specified | 2 visits: in fall production practice and cost data are collected; in spring whole- | Not applicable | Not applicable | 2 visits for the 2 cropping seasons | Repeated visits across the cropping season | Not specified | Twice a week | No field visit. Farmer recall and estimation |

| | EU | USA | Brazil | agri benchmark/ IFCN | The Philippines | India | Sri Lanka | Mauritius | Zambia |
|---|---|---|---|---|---|---|---|---|---|
| | | farm costs are collected | | | | | | | |
| **Number of commodity covered** | All major commodities | 15 | All major commodities | Beef and sheep, pigs, cash crops, dairy, horticulture, organic production | 32 | 28 | 12+3 export crops | 19 | 13+3 commercial crops + 3 flowers |
| **Data quality checking** | Iterative procedure between different responsible institutions | Not specified | Panel of experts and farmers | Panel of experts and farmers | Enumerator training, Spot-checking + back-checking | Enumerator training, Spot-checking + back-checking | Not specified | Diary/Book-keeping | Internationally recognized methodology promoted by the FAO |

## 2.2 Which sampling choices: Representative farm versus sample of farms?

The CoP data collection method, as applied to national data collection systems and global networks covered in this report, is effectively based either on large representative samples (e.g. FADN, ARMS, CCPC, CRS, CFS) or the representative farm approach (e.g. agri benchmark, IFCN, CONAB) (see also Table 1).

Differences in objectives of national and global data collection systems and differences in their use largely determine the methodology, in general, and the sampling strategy, in particular. According to Garnier (2012), if the goal is to evaluate heterogeneity and average production cost per country, per region, or for different farming systems, representativeness of the studied sample is critical (e.g. Methods ARMS, 50-sg report, France Arvalis-Unigrains Observatory, FADN). However, if the goal is to evaluate the production costs of performing farms or to characterise the economic impact of innovative practices (e.g. minimum tillage, low input system, organic farming, etc.), then the sample representativeness is still important but is secondary compared to the needs of having detailed and specific economic and technical data on technology, farm practices, timing of activities through the season, etc.

*Large representative samples across different countries:*

- The FADN (EU) is based on a representative sample, with regard to region, farm specialization and farm size. The sample covers more than 80.000 farms representing a population of about 6.4 million farms, which cover approximately 90% of the total utilized agricultural area (UAA) and account for about 90% of the total agricultural production of the EU. An individual weighting scheme is applied to each farm in the sample corresponding to the number of farms it represents in the total population. The weighing scheme allows to aggregate CoP values to different regional level (e.g. country, EU level) or by farm specialization and farm size (FADN 2010).

- The French data collection system for wheat and corn - Arvalis-Unigrains Observatory - is based on a sample of 4000 farms from 14 departments. A weighting scheme is applied to each farm in the sample corresponding to its relative share in national production (Garnier 2012).
- The USA's ARMS survey has a stratified and probability-weighted sampling design. Each farm sampled in ARMS represents a known number of farms with similar attributes so that weighting the data for each farm by the number of farms provides a basis for calculating estimates for the target population. Target populations for a commodity include all farms producing the given commodity (USDA-ERS 2012b).

- The 50-sg report in Ukraine is a representative sample of agricultural enterprises that exceed certain size limits (e.g. 200 ha; 50 cows, pigs, sheep (500 poultry; 20 workers) with the sample size containing around 9.000 farms.

- The CFS (Zambia) combines an exhaustive survey of large-scale holdings and a three-stage stratified sample to provide significant estimates at the district level for medium- and small-scale holdings. For the maize CFS, more than 10 000 holdings are visited.

- The CCPC surveys (The Philippines) are also based on a multi-stratified sampling procedure. For Rice and Maize, major producing provinces are given a higher weight than minor producing provinces, whereas for other products, only the top producing provinces are sampled. The number of households interviewed is not released.

- A three-stage stratified sampling procedure is also used for the CCPC survey (India), which looks for the representativeness of agro-climatic zones and holding size (CSO 2005):

- The primary sampling units (districts) are distributed into the different agro-climatic zones[3] of each Indian state, in proportion to the total area of all crops covered by the scheme.
- The same approach is followed at the secondary sampling unit (village), with each village selected for three consecutive years
- At the third sampling stage, agricultural holdings are randomly selected without replacement in each of the five holding size classes[4] previously established in the villages that were sampled at the second stage[5].

In CCPC surveys, national sample sizes vary from 4 500 holdings for paddy crop to nearly 300 holdings for coconut.

The CONAB (Brazil) applies the representative farm approach[6] to calculate CoP for different commodities. This approach does not rely on surveys to collect CoP data. Instead, the data collection is executed through a panel meeting of around 10-15 experts composed of CONAB experts, farmers, trade unions, academics, representatives from financial institutions, input suppliers and other relevant institutions.

The agri benchmark and the IFCN global networks are also based on the representative farm approach and represent a good example of its application at an international scale. The data collection is done via so-called 'panels,' that consist of networks of experts, advisors, farmers and statisticians located in different parts of the world who collect and process the data. The expert judgments of these panels decides all aspects related to CoP analysis, from representative farm selection to assigning CoP values to each cost category and activity.

The disadvantage of the representative farm's panel based approach is that the involvement of experts/advisors introduces subjectivity and personal perceptions in the data collection process. Additionally, an important weakness of the representative farm approach is low representativeness of collected data

[3] The definition of each agro-climatic zone is based on agro-climatic characteristics such as rainfall, soil type, cropping pattern and irrigation (CSO 2005).

[4] The five classes are defined according to the following thresholds of holding size: less than 1 Ha; between 1 and 2 Ha, between 2 and 4 Ha, between 4 and 6 Ha and above 6 Ha (DESMOA 2007).

[5] Each village is selected for three consecutive years.

[6] Other terminology often used for 'representative farm' includes for example 'typical farm', 'hypothetical farm', etc.

and its inability to capture adequately the variation of farming systems within regions. Finally, this approach is not well suited to capture farm structural changes (adjustment in technology, farm size, etc.). Any structural change is accounted for through exogenous adjustment of the representative farm in regular intervals. Although it is desirable to adjust the representative farm to reflect the actual farm structure, it may pose a problem of comparability of CoP data over time due to the fact that the characteristics of typical farms change over time (Langrell *et al*. 2012).

However, the representative farm approach is a relatively inexpensive methodology from the implementation viewpoint, with the possibility of its application on a regular basis on a wider regional scale, particularly in less resource-rich countries such as Asia, South America, Russia and Africa.[7]

A final distinct approach is applied in New Zealand. The farm monitoring system of New Zealand collects data from relatively large number of farms. However, the survey is based on voluntary participation of farmers, so it is not possible to make this system statistically representative at a regional/country level or across farm types. Neither is it based on representative farms as individual farms participate in the survey. For example, in the dairy sector about 10% of all farmers are in the survey, which is a relatively sizable number, but because farms are voluntary participants, results cannot be readily aggregated and compared across different regions, farm types, etc. Instead the data are extensively used for benchmarking, where individual farms compare their performance with the best practice among respondents (i.e. with the best performing farms) (Shadbolt 2011; Isermeyer 2012).

### *Recommendations*

Geographical coverage depends first on the geographical distribution of the commodity under consideration. It is obvious that if such a commodity is grown/bred only in a few regions of the country, national coverage is not necessary. It secondly depends on the final use of CoP estimates. If the aim is to assess a particular production system using a given technology or functioning under specific pedo-climatic/social conditions, a full national coverage is not required. Conversely, if national inferences are expected, the "representative random sample approach" is more appropriate[8]. Compared to the representative

[7] In most countries included in agri benchmark and the IFCN, the average number of representative farms is between 2 or 3 per commodity.

[8] Concerning the selection of representative samples: "If the population under study is homogeneous then the sample can be selected by simple random sampling, but if the population is very heterogeneous it can be divided into homogenous groups called "strata". Samples can then be selected from every stratum in proportion to the size of strata such that the sum of selected samples from the strata is equal to the desired sample size" (CSO 2005).

farm approach, the main strength of random samples is in delivering CoP data that can be compared across different dimensions (e.g. regionally, temporally and across farm types), depending on the survey design and sample stratification. However, a well-designed and representative survey is demanding on financial resources.

In spite of its cost (wide number of sampled units), there is a common agreement among the FAO "friends of the chair recommendations for cost of production surveys"[9] to recommend it as the best sampling practice (Lys 2012). Under this approach, diverse stratification alternatives are possible depending on the heterogeneity of the targeted population (CSO 2005). A variety of sampling techniques – such as stratification, systematic sampling, and probability proportional to size sampling – can be used to improve the efficiency of the sample design".

The main advantage of multi-stage sampling is that "it is cheaper and easier to create lists of holdings just in the selected areas, rather than for the whole country. Data collection is also cheaper because the sample holdings are concentrated in the selected areas, rather being spread around the whole country" (FAO 2005). But the same source warns that at the same time, "sampling errors are higher because of the "clustering" of sample in selected areas (…)."

In contrast, the representative farm approach is a financially cheaper option, which makes it attractive for less resource-rich countries. The representative farm approach is also more suited for collection of specific economic and technical data related to new technologies, farm practices, timing of activities through the season, etc.

Warning: Concerning large representative samples, the choice of sampling frames is another critical issue. It is quite common that population censuses serve as the basis for sampling, but they are usually conducted every ten years or more. During such a time lag, drastic changes are likely to occur in the agricultural population. In addition, in some cases, as in Zambia, agricultural components of agricultural censuses are insufficient to serve the elaboration of an appropriate list of household holders. Additionally, when available, agricultural censuses are a better basis for sampling only if they are really exhaustive and are not done according to a "minimal size criteria" that exclude a significant proportion of smallholders[10]. An alternative solution, experimented

[9] Friends of the Chair working groups of the UNSC were in charge to prepare "The Global Strategy to Improve Agricultural and Rural Statistics" in collaboration with the FAO and the World Bank, and through extensive consultations with stakeholders (WB-FAO 2010).

[10] "Some [countries] stipulate a minimum size that a holding must be in order to be included in a census or survey. Some concentrate data collection in major producing areas. This selective focus leaves smaller plots and remote parts of a country unrepresented in agricultural statistics,

in India for example, is to rely on multi-stage stratified sampling, the list of holdings being established at the last stage of sampling (generally the village). That way, there is no need to rely on an exhaustive list of holdings at the national level, and this ensures that the list of relevant holdings is updated since it is established on purpose.

## 2.3 Which frequency of data update

Experience shows that the frequency of CoP data update varies significantly across collection methods and countries. While some methods (FADN, 50-sg report, France Arvalis-Unigrains Observatory, the Indian CCPC survey, the Sri-Lankan CoP survey and the Zambian CFS) allow an annual update of all data including farm structure, this is not the case for ARMS, the Philippines CRS or methods of study based on the representative farm (agri benchmark, IFCN) (Garnier 2012) (see also Table 1).

*Some concrete examples:*

- Annually collected CoP:

For the FADN (EU), a complete data collection is made every year, but due to the complexity of the collection process and data check and validation, data release is delayed by about two years; i.e. the most recent data available are two years old. For the Arvalis-Unigrains Observatory, the release of data is delayed approximately one year (one harvest before). For the current year, Arvalis-Unigrains Observatory provides estimations (Garnier 2012). For the Indian CCPC survey, data are generated throughout the year for the two cropping seasons but they are made public only three years after their year of collection in order to not interfere with the pricing policy of Indian State. In the Zambian CRS, data are collected annually and released within 5 months. The Sri Lankan CoP data are annually surveyed and released in a booklet but not online.

- Multi-years data collection with annual updates:

Concerning the ARMS method (USA), CoP estimates are based on farm surveys conducted every 4-8 years for each crop. For non-survey years, CoP are estimated using structural data from surveys and annual data on prices,

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although these areas may account for a majority of the country's food insecurity and poverty. The omission of small-holder and household plots also deprives decision makers of information about local subsistence strategies or the amount of income households receive from selling produce from gardens and small plots" (WB-FAO 2010).

production and other indicators. The CRS approach (Philippines) is similar to benchmark surveys and is conducted every three to five years, with annual estimated updates[11] based on other price surveys[12]. This can cause discontinuities in data when new survey data replace non-survey estimates, depending on how much technical and/or structural change occurred in the sector between the survey years, as well as when changes occur in the sampling, questionnaire, and other data collection procedures. Data for major crop and livestock activities (corn, soybeans, wheat, cotton, dairy, and hogs for the ARMS; palay (rice) and corn for the CRS) are gathered more often than that for other commodities (other feed grains, other small grains, sugar beets, rice, peanuts, tobacco, and poultry for the ARMS; rootcrops, legumes, vegetables, fruits, coffee, nuts and milkfish for the CRS) (BAS website, USDA-ERS 2012a).

- The "representative farm" approach:

In the agri benchmark and IFCN methods, input prices, selling prices and changes in yields are updated every year. A complete update of the representative farm (i.e. farm technology and size) is usually done every two to four years depending on the speed of structural change and innovation. The release of CoP data in agri benchmark and IFCN methods is timely, given that it is available for the current year (Garnier 2012; Isermeyer 2012). In CONAB (Brazil), the technological coefficients used for CoP allocation are updated every three years. However, the update of the coefficients may be done more frequently if significant structural changes took place (e.g. due to change in productivity, mechanization, irrigation method, etc.) (CONAB 2010). Similar to the case of ARMS, updating the representative farm or technological coefficients every two-four years may lead to discontinuities in time-series.

A regular update of CoP data is crucial for evolution of farm competitiveness and farm structural change. Methods based on representative sampling are better suited to study the evolution of production costs and changing structure of farms if updated on a regular basis. The methods based on the representative farm approach are not able to fully capture the evaluation of farm structural change related to CoP, because farm technology and size are predefined and the representative farm approach has limited coverage of farm heterogeneity.

[11] In the particular case of highly variable contexts, the Moroccan representative of the FAO "friends of the chair recommendations for cost of production surveys" commented that « interpolation between years has to use some indices that take into account the year condition in terms of the weather, the inputs availability, and other relevant information specific to that crop such as some technology » (Lys 2012).

[12] While farm gate prices like cost of seeds, irrigation fee, lease rental etc. are collected in the Farm Price Surveys (FPS), fertilizer prices proceed from the Weekly Cereals and Fertilizer Price Monitoring (WCFPM), and labour costs are based on the nominal wage from the Agricultural Labour Survey.

Further, updating the representative farm in irregular intervals makes it problematic to track the evolution of farm competitiveness over time (Garnier 2012; Langrell et al. 2012).

It is noteworthy that some countries have not performed any CoP survey since they stopped controlling agricultural market prices (last CoP survey in 1986 in Ethiopia, no CoP surveys between 1986 and 2009 in Mali), while others perform such surveys on an ad hoc basis according to government needs and/or the availability of funds (i.e. Morocco in 1991 and 2006, and Ethiopia and the Philippines with fluctuating frequency).

***Recommendations***

There is no observed common practice in terms of frequency of collection and update of CoP data across surveyed countries and methods. The frequency of data collection for the survey approach varies widely; between one year and up to eight years. It is recommended to adjust the frequency of data collection to reflect the importance of the commodity and the development of sectoral and farm structural change. Sectors subject to faster structural change need more frequent data collection as opposed to the less dynamic sectors. Indeed, FAO experts do not systematically recommend conducting CoP surveys annually, due to the costs incurred. Instead, they recommend to respect an interval of a maximum of three or five years between surveys, depending on the pace of structural changes in the sector (FAO 2011; Lys 2012).

More important commodities in terms of production, area use and trade are recommended to be more frequently surveyed than other commodities. Survey frequency should also depend on the inter-annual variability of CoP in the country considered given that "normal" years are more difficult to catch in highly variable contexts. Further, it is recommended to provide estimates of CoP for non-survey years using annual data of relevant indicators (e.g. prices, production).

An accompanying issue is the time lag in the release of CoP data. This is strongly linked to the data collection method and availability of financial resources and human and infrastructural capabilities in collecting, processing and checking the data. Delays (up to 3 years) can be observed for survey based approaches, whereas the methods based on representative farms are usually able to deliver data with small or no delay. It is recommended a timely update of CoP data in order to increase their usefulness for policy decision, research and market agents.

To favour timeliness, one recommendation is also to focus CoP surveys on few major crops during the first implementation years while accumulating experience in questionnaire design, data collection and data processing. Once

the CoP methodology is well-established, the coordination between the different services and staff involved is smooth, and the time lag for data diffusion is acceptable, the commodity coverage can be widen. When required, the FAO "Friends of the chair group for cost of production surveys" (FoC) recommends to prioritize the major commodities, considering as selection criteria: "the importance of the commodity by value, by area, the commodity's importance to food security, availability of budget , and the importance to the country's foreign trade balance" (Lys 2012). In practice, some countries like the Philippines opted for surveying major crops on a regular basis (Palay and Corn in the Filipino CCPC survey; corn, soybeans, wheat, cotton, dairy, and hogs in the ARMS) while surveying others on a rotating or ad hoc basis. Not only does a commodity selection aim at controlling costs, but it additionally lowers response burden.

## 2.4 Recommendations to minimize recall bias

"Questionnaire design plays a central role in the data collection process as this has a major impact on respondent behaviour, interviewer performance, collection cost and respondent relations and therefore on data quality" (Friends of the Chair on Integrated Economic Statistics 2012). The main recommendations in this area are well targeted questions in terms of content, wording and units. Indeed, it is not worth elaborating large questionnaires (including sections on technology, membership to an association of producers, etc.) if the whole richness of information is not analysed afterwards. Focused questions reduce respondent fatigue. In addition, the FAO expert group meeting on cost of production and price suggests taking care to avoid duplicating/overlapping content and indicators contained or coming from other surveys (FAO 2011). The Friends of the Chair on Integrated Economic Statistics (2012) go further in their recommendations about questionnaire's content based on the increased availability of administrative data: "questionnaires should be developed with the possibility that part of the survey results will be provided by respondents while another part will originate from administrative sources".

Concerning wording, the most appropriate would be to formulate questions with the specific terms used by the respondents to facilitate their understanding. This point can be addressed during the pre-test of the questionnaire. Additionally, the Friends of the Chair on Integrated Economic Statistics (2012) insist that countries with multiple official languages translate questionnaires in all their official languages.

Finally, for the reliability of answers, there is a consensus among the FoC to respect the units used by respondents during data collection, even if this requires further conversion or recalculation when processing data (Lys 2012).

For instance, variable costs are generally better informed at the enterprise level, while the easiest unit for reporting overhead costs is the whole farm. In this case, overhead expenses can be asked at the farm level and allocated to the appropriate enterprises afterwards. Respecting local units or the unit used in farmers' records will also optimize farmers' ability to report and provide reliable data (Lys 2012).

In terms of data collection methods, direct measurement (of area and yield) is ideal to maximize data accuracy (i.e. Ethiopian case). Similarly, farm records when completed daily are a powerful tool to record exhaustive input and output transactions as well as farm operations (i.e. The Republic of Mauritius). The Ethiopian government experimented with another option, relying on locally based enumerators who settled in the sampled villages during the whole time of the survey (6 months) (Lys 2010). This permitted them to visit the sampled farms weekly or even twice a week. Given the human and financial cost of frequent visits, other countries have opted for a minimum number of visits (one to four visits). In these cases, visits have to be scheduled during the cropping year to occur closely to the critical operations, consequently reducing farmer recall bias. When only one visit is planned, the questionnaire should be well focused to avoid long interviews and respondent fatigue.

The use of highly skilled and/or trained enumerators is another means of optimizing an understanding of the questionnaire. This is the option followed in Mali where researchers were asked to apply CoP questionnaires (Lys 2010). At the same time, such an option does not ensure that the enumerator speaks the local language or manages local units. Sri Lanka has experimented with another very cheap option for the calculation of tea, rubber and coconut production costs by large estates. It consists of annually mailing the same questionnaire to large estates only, as these estates systematically fill record books. But even under this condition, the non-response rate is elevated (FAO/APCAS 2008). From these alternative methods, there is no clear recommendation in the literature: "The choice of the survey data collection method (mail, telephone, electronic, interview, etc.) would depend on the country's resources, preferences and characteristics" (Friends of the Chair on Integrated Economic Statistics 2012).

## 2.5 Recommendations on CoP data processing and dissemination

After data is collected, spot-checking and back-checking, editing at local and regional/provincial and national levels, and final processing are the usual steps followed before the final dissemination of data (see **Error! Not a valid bookmark self-reference.**). Spot-checking is ordinarily performed by field supervisors. It is a crucial instrument to reduce consistency errors and to reduce

the workload in the following steps. Back-checking is conducted afterwards and does not systematically induce re-interviewing. To underline the significance of such steps, note that under the Ethiopian system, half of all questionnaires were revised during re-interviewing done by the supervisory staff for the Cost of Production 1974/75 Sample Survey (Lys 2012).

Editing can be done repeatedly including some manual editing at the district level and further electronic editing at higher levels. They constitute one more occasion to look for inconsistencies and invalid data and to address non-response.

Finally, software is used to process CoP data. The more common are FARMGAP, IMPS, CSPro. The existence of software tools does not preclude the persistence of manual calculation at some stages: for instance the Philippines are still manually updating CoP estimates each year. Neither does it preclude further checking/updating based on qualitative judgment. In Mali, when CoP surveys were still on-going, a team of experts was convened twice a year to review CoP estimates (Lys 210). As these multiple stages of data checking, editing and processing also inform on the general weaknesses and strengths of the survey design. Lys (2010) recommends the design and implementation of a continuous improvement program aimed at conducting "research into all aspects of the survey program (questionnaire content, collection techniques, data validation, estimation and analysis) with the goal of arriving at recommendations to improve overall results."

Data access and utilization are a crucial point driving the cost/benefit ratio in conducting a CoP survey. Unfortunately, due to confidentiality restrictions, time lag in data processing, and/or interference due to implications for public policy making (i.e. the setting of Minimum Price Support in India), data access is not always straightforward. Good examples of an extensive application of data for policy purposes and in academic studies are the ARMS in USA and the FADN in EU. This is mainly because they have the advantage of being statistically representative and are accessible for relevant policy analysis and research projects. For example, in the case of FADN, disaggregated data are made accessible for research purposes on a project basis granted under special confidentiality arrangements.

Delay before public availability, impossibility of disaggregating data or data incompatibility with usual software (excel, access, SAS) sometimes hamper optimal utilization of CoP data by academics or even policy support services. In India, for example, academics have requested disaggregated information, but cost concepts are activity-wise summarized and averaged at the state level so disaggregation by by farm size, technical level etc. are impossible despite the fact that all the data required to answer these academic queries are gathered in the CoP questionnaire.

Moreover, lags in publication are highly variable from one country to another, depending on the amount of data collected, the organization between services and other considerations. Ethiopia was, for instance, able to release CoP data 5 to 6 months after the closure of the reference period. This is also the case in Zambia where the Crop Forecast Survey serves the pricing policy. In the USA and EU (ARMS and FADN data, respectively), datasets are published 2 years after or later. In India, in spite of fast data processing to inform the setting of minimal price supports (MPS), CoP data are publically released only three years after to avoid interference with the MPS implementation. In any case, swift publication theoretically contributes to agricultural sector monitoring and on-time decision making.

More generally speaking, FAO (2013) insists on the adequacy of national statistics with data producers, providers and end-users' needs and proposes six criteria of data quality requirements for statistics dissemination. They are (i) their relevance (and completeness), which is the degree to which they meet current and potential user's needs; (ii) their accuracy or closeness to the true values; (iii) their precision (variability, or any other measure of uncertainty); (iv) their comparability across countries; (v) their coherence; (vi) their timeliness and punctuality; and (vii) their accessibility and clarity. In addition, FAO insists on the need for "explanatory notes on concepts, definitions, scopes and reference period to accompany publication of the data collected" (FAO 2013).

# 3

# How to calculate CoP

## 3.1 Which type of cost?

CoP is an economic indicator assessing the economic performance of production. Cost is defined as the value of a factor of production (input) employed in the production of final outputs. The classification of production costs can be made along several dimensions. Table 2 summarises seven possible ways of categorising production costs (AAEA 2000; Cesaro *et al.* 2008).

For the purpose of the present study, a possible classification of CoP that might be relevant from a methodological point of view is based on whether or not costs are traceable to a specific farm activity (i.e. direct versus indirect costs). A direct cost is a cost that can easily and conveniently be traced to a particular farm activity (e.g. commodity). For example, in most cases the use of fertilizer is a direct cost of producing a particular crop.

Conversely, an indirect cost is a cost that cannot be easily and conveniently traced to a particular farm activity. For example, if a farm produces several crop commodities, a cost item such as machinery maintenance is an indirect cost that benefits all crops for which the machinery was utilised. Here, the reason is that machinery maintenance costs are not caused by any specific crop but are common to all. Indirect costs are incurred to support multiple activities (e.g. multiple crop commodities) and cannot be traced to each individually.[13] Indirect costs are usually constant for a wide range of outputs and are grouped under fixed factors.

It is possible to classify almost any kind of cost as either direct or indirect.

[13] Other terminology often used is *joint costs* (or shared costs). Joint costs are costs incurred in a production process involving more than one product whose production cannot be separated from each other (e.g. wool and sheep meet production are joint products hence all sheep costs are joint costs; inputs purchased for the farm as a whole such as overheads). Joint costs can occur either as direct costs or as indirect costs. Some inputs such as fertilizer or lime, which are normally viewed as direct costs and can be assigned to a particular commodity, may have an inter-temporal or residual carry-over effect that may impact the production of other commodities (AAEA 2000).

Labour costs, for example, can be indirect, as in the case of maintenance personnel and managerial labour; or they can be direct, as in the case of hired labour for specialised work carried out on a particular commodity. Similarly, other costs such as machinery and equipment maintenance costs, such as for tractor depreciation, are typically classified as indirect costs, while machinery and equipment used for a specific commodity (e.g. corn sowing machines), are included in direct costs.

Considering monetary flows, a second possible distinction is made between cash costs and noncash costs. For cash costs, monetary payments and the consumption of inputs are realised in the same period (e.g. cash payments for fuel, fertilizer, seed, repairs, and similar items). For non-cash costs, either the payment is not realised (opportunity cost of own inputs) or there is a time lag between the time when payment was made and when the input was used (e.g. capital depreciation). Depreciation costs account for the declining value of farm assets such as machinery and buildings. Opportunity costs (also referred to as implicit cost and/or imputed cost) represent the cost of own inputs (e.g. own land, labour and capital). Because own inputs are used at farm level, they forgo income which could be earned if they were employed in alternative activities. The opportunity cost represents the value of own inputs in the next best alternative use (e.g. the opportunity cost of family labour is off-farm wage; the opportunity costs of own land is market rental price). The consideration of opportunity costs is one of the key differences between the concepts of economic cost and accounting cost. The latter usually does not consider the opportunity costs because the actual payment transactions are not realised. Economic costs consider all explicit and implicit costs incurred by farms including opportunity costs (see further).

**Table 2: Typology of production costs**

| Classification description | Type of costs | Description | Examples |
|---|---|---|---|
| **In relation to farm activity** | -Direct cost<br>-Indirect cost | Direct cost can be assigned directly to a farm activity (e.g. commodity). Indirect costs are incurred per group of products or per farm as a whole. | -Direct cost: fertilizers, seeds<br>-Indirect cost: overheads, machinery maintenance, depreciation |
| **In relation to cash flow** | -Cash cost<br>-Noncash cost | Costs based on whether monetary payment follows input flow in a given period. | -Cash cost: fertilizers, seeds, hired labour, rental costs<br>-Noncash cost: depreciation, opportunity cost of own inputs |
| **In relation to whether actual expenses were incurred** | -Explicit cost<br>-Implicit cost | Explicit costs are actual incurred expenses. Implicit costs (or imputed costs, or implied costs) are not associated with actual expenditure payments. | - Explicit cost: expenditures on fertilizers, seeds, hired labour, rental costs<br>- Implicit cost: opportunity cost of own inputs |
| **In relation to unit of production** | -Variable cost<br>-Fixed cost | Variable costs change with production level; fixed costs are independent of production level. | -Variable cost: seed, fuel, machine repairs, fertilizer<br>-Fixed cost: depreciation on buildings and machinery |
| **In relation to unit of comparison** | -Total cost<br>-Average cost<br>-Marginal cost | The distinguishing criterion is unit of measurement with respect to which costs change, such as per farm, per hectare, per unit of production. | |
| **In relation to usage** | -Expendables<br>-Capital<br>-Capital services | Expendables are inputs consumed in a given period. Capital is a stock concept. Capital services are services obtained from the capital stock in a given period. | -Expendables: seed, fuel, feed<br>-Capital: machinery, buildings, equipment, land, human capital<br>-Capital services: services provided by equipment, labour, etc. |
| **In relation to farm operations** | -Operating costs<br>-Overhead costs | To what extent they related to operation of farm processes. | -Operating: seed, fuel, feed<br>-Overhead costs: the purchase of land, buildings, machinery |

Another standard classification of costs used extensively in economic theory is according to its variation with respect to the unit of production. Variable costs change with production level, whereas fixed costs are independent of production level. In other words, variable costs are affected by the farm's actions in the period under consideration, whereas fixed farm costs incur independently of the actions undertaken by the farm in the period under consideration. Note that some fixed costs may be quasi-fixed implying that they are flat within a certain range of production but change if the range is overshot (e.g. machinery).

With respect to the unit of comparison, costs can be classified as total costs, average costs and marginal costs. Total costs represent the value of all inputs (cash and non-cash) a farm uses in a given period and they are the sum of variable and fixed costs. Average costs are total cost split per unit of measurement, such as per hectare or per unit of production (e.g. per tonne). Further, average costs can be distinguished by type of cost, such as average fixed or average variable cost. The marginal cost is the change in total cost that arises due to the change in one additional unit of output or input.[14] The marginal cost with respect to output is total cost change when production changes by one unit. Equivalently, the marginal cost with respect to input is the change in total cost when input use changes by one unit (e.g. marginal cost of labour, marginal costs of land).

Another distinction of costs is in terms of input usage during the production process. Expendables are inputs that are completely used up or consumed during a single production period. Capital is a stock that is not used up during a single production period but provides services over time. Capital services are the flow of productive services that can be obtained from a given capital stock during a production period.

Finally, costs can be distinguished in the link they have with respect to farm operations. Operating costs are related directly to the operation of farm activities. They can also refer to the costs of operating a specific farm activity (e.g. wheat production). Operating costs can be either variable or fixed costs.15 In contrast, overhead costs are costs incurred on the purchase of factors such as land, buildings, machinery and equipment to be used in the production process. Unlike operating costs, overhead costs are one-time expenses that ensure that a given farm production process is operational. Overhead costs are fixed and are, therefore, independent of the level of production.

[14] Expressed mathematically, the marginal cost is the first derivative of the total production costs.

[15] For example, AAEA (2000) recommended that all expendable costs to be classified as operating costs and all other costs to be grouped as overheads in the commodity cost calculation method applied in the US.

***Recommendations***

Key challenges in accurately calculating production costs is to assign each cost item to a specific unit of interest (e.g. per tonne of a production), which strongly depends on the cost type. Particularly problematic are shared costs that are not directly linked to a specific product but are incurred across multiple products (e.g. indirect costs, fixed costs, overhead costs), as well as costs for which payments are not realised and need to be imputed (e.g. opportunity cost of own factors). These cost categories require special attention and application of an appropriate technique to obtain accurate cost values. For shared costs, an allocation technique must be applied to split the costs incurred on multiple farm activities into specific unit of interest. The same holds for costs for which payments are not realised, which is usually associated with farm owned factors of production (e.g. labour, capital, land). To identify appropriate cost values, there is a need to apply an appropriate imputation technique to identify these factors' opportunity cost. These cost types are subject to potentially significant errors if suitable imputation and/or allocation techniques are not established. For this reason expert advice is recommended since the application of different techniques requires specialised knowledge of economic theory, agro-technological processes and/or quantitative methods.

Cost types that are directly linked to the production of a specific farm activity (e.g. direct costs) can be more easily identified per unit of interest. In this case the identification and calculation of cost of production does not pose a significant methodological challenge in terms of the need to use sophisticated techniques and thus it is less dependent on specialised expert knowledge.

## 3.2 Which unit of observation?

The unit of observation differs between surveyed countries, methods and cost types. Some countries which collect data through representative samples collect CoP data only for the whole farm (e.g. FADN) or by combining data collected by commodity or for the whole farm depending on the cost type (e.g. ARMS). Methods based on representative farms also collect data by commodity or for the whole farm depending on the cost type (IFCN, agri benchmark, CONAB).

One key factor that determines whether data are collected by commodity or the whole farm is the cost type. Data directly observed per commodity (e.g. direct costs) can be directly collected per commodity through farm surveys. The collection of costs at the commodity level is relatively easier for direct costs then for fixed costs and overheads such as machinery, buildings, management, and family labour. The majority of direct costs are traceable and can be assigned to a specific commodity, whereas fixed costs are typically used to

produce multiple farm commodities, and thus it is not straightforward to allocate them to a specific commodity. For this reason, fixed costs are usually collected per farm as a whole or group of commodities and then an allocation technique is used to allocate them to specific commodities.

*Concrete examples from national data collection systems:*

- Holding-wise CoP data:

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

- Plot-wise CoP data:

In the 2005 Mauritius CoP survey, operating and fixed costs were collected at the plot level (or group of plots in the case of sugarcane planters holding more than one plot, since in this case, they usually do not keep separate accounts for each plot). Total costs could then be calculated per ha and per kg of product.
Primarily aimed at forecasting the future crop production of the current cropping season, the CFS (Zambia) does not include CoP calculation. However, they compile enough household- and field-level data on input use and production to compute them. This is 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 all overhead costs are not covered by the CFS, which is the reason why indirect costs were not calculated by Burke *et al*. (2011).

- Holding-wise data collection and estimation of commodity-wise CoP:

The ARMS (USA) collects commodity-specific costs (e.g. direct cost), input quantities and production practices by commodity (e.g. seeds, fertilizers, chemicals). Non-specific costs (e.g. overheads) are collected for the whole farm and are assigned to specific commodities based on an allocation formula. The same approach is followed in the Philippines, allowing the calculation of average production costs and returns per hectare, per farm and per kilogram (even though the whole farm costs are not released in the Philippines CoP database[16]); 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

[16] http://countrystat.bas.gov.ph/?cont=12

are mono-specialised in Sri Lanka, they almost correspond to crop-wise data. Moreover, CoP calculation for tea, rubber and coconut in Sri Lanka covers costs of manufactory and transport to the place of export in addition to cultivation costs. This is also the option used in India according to the so-called "crop complex" approach, meaning that data is collected on all crops grown on all plots farmed, and then allocated to each single crop (Lys 2012). Crop-wise farm level data are then converted into zone level and state level ones.
It is noteworthy that the data collection process in ARMS is implemented in three phases. It starts during the fall when production practices and cost data are collected, and finishes in the spring when a follow-up interview collects data on whole-farm costs like overhead, interest, and taxes (USDA-ERS 2012b):

- *Phase I*: farmers selected for inclusion in the survey sample are screened to verify their operating status and to determine whether they are producing commodities targeted for data collection. This helps to improve survey efficiency in phases II and III.
- *Phase II***:** data are collected at the individual field or production unit level. Phase II is a series of commodity surveys conducted to obtain physical and economic data on production inputs, management practices, and commodity costs of production.
- *Phase III***:** data are collected on the whole farm level. Data are collected from a nationally representative sample of farmers in order to analyze the farm-level economic situation in the reference year. Farmers interviewed in Phase II are also included so that data from both surveys can be merged.

The unit of observation in methods based representative farm approach (IFCN, Agri benchmark, CONAB) is commodity level (e.g. per ha, per animal). The CoP can be split up into a quantity and a price component allowing detailed analysis across commodities and regions. This method constructs the CoP data starting from the schedule of different commodity-specific activities up to the whole farm expenses. As described above, the main source of CoP data are panels of experts combined with the data from the bookkeeping of real farms and additional sources. This implies that direct costs (e.g. fertilizers, seeds) are identified per commodity, whereas overhead costs are collected by the panel for a group of commodities or for the whole farm and then assigned to specific commodities based on an allocation formula (Garnier (2012; Isermeyer 2012). It is important to note that the representative farm approach usually provides more detailed cost disaggregation and makes easier the distribution of cost items among the different farm activities than do methods based on surveys.

***Recommendations***

Although the unit of observation varies across countries and methods it is recommended that the choice of data collection of a particular cost category should be mainly driven by the ability of farmers to report reliable data. For cost categories for which farms can report CoP per commodity, these cost items should be collected for the commodity or enterprise in question. For cost categories used to produce several commodities, the collected data should be per group of commodities or at the whole farm level, with an allocation formula applied to split these costs to a specific unit of observation. For example, cost items such as seeds and fertilizers can be relatively accurately collected per commodity from farmers directly, whereas overhead costs on buildings and machinery can be best collected at the whole farm level or group of commodities for which they are used.

## 3.3 Accounting costs versus economic costs?

There are two conceptual approaches used in the general businesses management and economic literature with respect to CoP analysis and their practical application. These two concepts refer to economic costs developed within economic science versus accounting costs applied in the business management field. The key difference between the two concepts is in cost categorization and, in particular, in terms of cost representation. Accounting costs include explicit costs of farms which are actually incurred by farms. They include actual outlays or expenses incurred. The economic CoP usually exceeds the accounting costs of production because they include both explicit accounting costs and implicit costs. For example, economic costs also include costs of family labour, for which actual expenses were not incurred, which is not the case following the accounting principle.

To be able to conduct economic analyses with CoP data and to ensure comparability of CoP across and within farms/commodities/regions, it is important to collect/calculate economic costs. The accounting approach will fail to provide a complete picture on CoP as implicit costs are not covered when using this approach for data collection. The application of the accounting approach may thus lead to significant gaps in data, which will vary by farms and/or regions depending whether farms use their own factors in production or purchase them in the market.

In practice, accounting costs are more easily available due to the fact that the accounting principle is the most commonly applied method for recording farm

activities in high income countries. Even if farms do not keep records,[17] explicit costs can be valued more accurately by farmers or experts because they are associated with actual market transactions. Collecting data on implicit costs is more challenging because they mostly concern costs categories for which there are no market transactions. An appropriate method needs to be applied to value implicit costs. The valuation of implicit costs is relevant for the following two types of farm inputs:

- *Valuation of farm owned factors of production (e.g. labour, land, and capital)*: When the farm is the owner (supplier) of factor used in production, there are no monetary transactions associated with these factors. The opportunity costs need to be computed for them. The opportunity cost of a factor represents its value in its next best alternative use. For example, a good approximation of the opportunity cost of farm owned land is the market rental price of land.
- *Valuation of in-kind farm expenses*: In the rural economy, transactions are often realised in-kind rather than in cash. For example, this may involve labour exchange between farms or payment of land rent in the form of output produced on the land (e.g. share tenancy arrangements). The market prices of in-kind transactions need to be collected to estimate their monetary value.

## 3.4 How to value farm owned factors of production

This concerns, in particular, the valuation of land, labour and capital owned by farmers and used in the production process.

***Opportunity cost labour***

According to Mishra (2012) and following the human capital literature, the opportunity cost of time allocated to family labour is the maximum of the value of a unit of time allocated to off-farm work or leisure. The total time is defined as the sum of farm, off-farm, and leisure time. For off-farm work to occur the opportunity costs must be equal to the off-farm wage rate, so the off-farm wage is an appropriate proxy for the price of unpaid family labour. Further, Mishra (2012) notes that skills of family labour need to be also taken into account when calculating its opportunity cost. In the agricultural productivity literature, unpaid labour is valued at the wage for "similar skilled" workers (controlling for gender, age, education, and occupation). On the other hand, Isermeyer (2011) arguments that a good proxy for the opportunity cost of family labour should be the payment that the farmer has to incur for hiring a person who

[17] Which is the case of many developing countries.

replaces the farmer when (s)he is on vacation.

The valuation of opportunity costs of labour is particularly relevant if CoP data are used for inter-farm competitiveness analysis, in particular when comparing the performance of small-scale farms versus large-scale farms. Small farms use predominately family labour while large farms tend to rely predominantly on hired labour. If the opportunity cost for family labour is not accurately measured then the inter-farm comparative analysis may result in biased results (Isermeyer 2012).

The most common proxy used to measure opportunity costs of family labour in different countries and methods includes either off-farm wages of family labour or wages of hired agricultural labour (
Table 3).

*Concrete examples from national data collection systems:*

- Family labour costs valued at off-farm wage

Before revising its methodology in 1995, ARMS (USA) valued unpaid family labour at the hired labour wage rate for all agricultural employees. Since switching to the AAEA task force recommendations (AAEA 2000), unpaid family labour is valued at an estimate of the off-farm wages paid to farm operators working off-farm. The CONAB (Brazil), Australia and agri benchmark also use off-farm wage as the opportunity cost for family labour.

- Family labour costs valued at the agricultural wage

In the Arvalis-Unigrains Observatory (France), the number of hours assigned to active full-time family labour is 1600 per year, which is multiplied by the hourly regional labour cost to obtain the total family labour cost. Concerning the FADN (EU), the family labour force is remunerated at the level of the regional agricultural labour wage. In Asian and Sub-Saharan African countries, the opportunity cost is commonly valued at the local agricultural wage. It is based on the nominal wage rate from the Agricultural Labour Survey in the Philippines, on the statutory wage or the local market rate in India, on the local average wage earned by paid employees in Mauritius, and on the median hourly wage reconstituted at the local level for each kind of farming activity by Burke *et al*. (2011) for Zambia. Thus, it implies that different sources of information can be used - specific agricultural labour surveys, statutory levels or information on the local labour market – with more or less possibilities to differentiate costs according to farming activity or time in the cropping season. Additionally, wages are weighted according to the World Bank Consumption Adult Equivalent by Burke *et al*. (2011) for Zambia but are not differentiated

according to age, sex or skills in other studies

In the 50-sg report method (Ukraine), hired labour costs come directly from accounting records, and family labour cost is not valued. Not accounting for family labour costs is a relatively minor problem for the 50-sg report because the farms surveyed are mostly medium and large agricultural holdings which hire most of the workforce used on the farm.

***Opportunity cost of land***

Conceptually, the opportunity cost of holding land represents the current agricultural value of the land multiplied by an appropriate interest rate. This value should be adjusted by other costs associated with land ownership, such as property tax and maintenance costs, to obtain the total costs of holding land. In practice, the calculation of the opportunity costs of land ownership is complex because of a variety of reasons though particularly related to difficulty in finding an appropriate interest rate or estimation of land value if markets are thin (AAEA 2000).

The most commonly applied proxy to calculate the opportunity cost of land is based on rental price information. However, due to the existence of a wide diversity of rental contractual arrangements between tenants/farmers and landowners across regions and countries, such as cash rent and share tenancy arrangements, the approach based on rental price data may not be applicable and an alternative method needs to be used taking into consideration specific local conditions prevalent in the land market.

Based on the methodology developed by AAEA (2000) for the USA, several alternative ways to estimate opportunity costs for farm owned land can be applied depending on the market conditions:

- In regions where cash rental markets are well developed, the cash rent paid for land use in agricultural production represents the best proxy for the opportunity cost of holding land.

- In regions where share tenancy arrangements are prevalent, the opportunity costs should be calculated based on these arrangements. The share rental rates need to be converted to a cash-equivalent value taking in consideration all cash and non-cash payments between tenant and landowner (e.g. the value of production share given to the landowner, landowner contribution to input costs).

- In regions where land is operated predominantly by farming landowners, rental rates are not suitable for estimating land opportunity costs. Instead the opportunity cost should be calculated from the market (sale) price of agricultural land by multiplying it with an appropriate real interest rate and adjusting it by other annual land costs (e.g. maintenance costs, property tax).

- In regions where rental and sale markets for agricultural land are not developed, the opportunity cost needs to be estimated based on the cost, yields and returns of land used in agricultural production.

*Concrete examples from national data collection systems:*

- Cost of land valued at the cash rental rate

ARMS (USA) values land according to the average cash rental rate, by cultivated commodity and region (USDA-ERS 2012a). In the FADN (EU), the opportunity cost of owner-operated land is estimated on the basis of the rent that farm owners would need to pay for renting the land instead of owning it. More specifically, the FADN approximates the opportunity cost of land with the rental rate paid for land renting on the same farm, otherwise if there is no rented land on the farm, the average regional rental rate for the same farm specialization is applied (European Commission 2013). The Observatory Arvalis-Unigrains (France) estimates land opportunity costs in a similar way to the FADN. The agri benchmark uses the regional rental price as a proxy for land opportunity costs. In India the CCPC survey bases its estimation on prevailing rents in the village for a similar type of land. In the 2005 Mauritius CoP survey, no distinction by type of land is made and costs of owned land are based on the estimated average rent paid at the local level.

- No valuation of cost of land

The 50 sg method (Ukraine) does not take cost of farm owned land into consideration. This issue is less relevant for the 50 sg methods because it considers only medium and large agricultural holdings, which rent around 99% of the land they use (Garnier 2012). Neither is it taken into account in the Philippines, where only lease rental and rental value of land are considered, valuated at the price reported by the holder.

***Opportunity cost of capital***

The opportunity cost of capital is the expected return forgone by investing in

agricultural assets (e.g. machinery, equipment, farm buildings, breeding animals), instead of investing the same sum in alternative investments. In the economics' literature, it is often approximated by the interest rate of return that farmers could earn in financial markets.

*Concrete examples from national data collection systems*:

The ARMS method (USA), uses long-term interest rates on farm assets (e.g. machinery, equipment and buildings) and short-term interest rates on operating capital (e.g. fuel, repairs). A long-run rate of return to farm assets out of current income (10-year moving average) is used as the interest rate (1.23% for 2001-2010) to estimate the opportunity costs of farm assets. Opportunity costs for operating inputs is based on the 6-month US Treasury Bill interest rate (i.e. next best "risk-free" alternative return) (AAEA 2000). The agri benchmark applies a similar approach to that of ARMS.

In the FADN (EU) the cost of own capital is estimated based on the return to the equivalent value of capital invested in a bank. Own capital value is estimated as the average value of assets (closing plus opening valuation divided by two) multiplied by the real interest rate. Operating capital is not valued in the FADN (European Commission 2013). In the Arvalis-Unigrains Observatory (France) the cost of capital represents charges on operating capital, machinery and buildings. The 50 sg method (Ukraine) considers the accounting value of interest payments and equity costs.

Costs of owned operating capital are calculated according to a pre-established rate in the Philippines' CRS survey (16%), in the Indian' CCPC survey (12.5%), and in the 2005 Mauritius CoP survey (5%[18]). The large range of rates used in these surveys is not surprising since they are based on national interest rates. It is more surprising that interest rates are not attributed to the same period across countries (on the whole duration of the cropping season in Mauritius and the Philippines, or on half of the year in India). Among these cases, the imputation rule concerning the interest rates on owned fixed capital is specified only in the Indian case (10%).

***Recommendations***

Several recommendations can be drawn from the experience of CoP methodologies applied in different countries and global networks:

- Family labour: The recommended measure of the opportunity cost for unpaid family labour is off-farm wage for "similar skilled" workers.

[18] This represented the average saving rate in Mauritius in 2005.

- Farm owned land: The recommended valuation of farm owned land is the cash rental rate of agricultural land. If cash rental markets are not well developed, then other methods should be applied depending on market conditions prevailing in the region: (i) the cash-equivalent values of share rental agreements is recommended in regions where share cropping is predominant, (ii) the value based on land sale prices and real interest rate is recommended in regions where land is predominantly owner-operated, and (iii) the value based on estimated net land return is recommended in regions where rental and sale markets are not present.

- Farm owned capital: The recommended measure of the opportunity cost is an appropriate interest rate depending on the type of capital. If the costs are calculated and compared over time, the use of real interest rate is recommended instead of the nominal interest rate.

**Table 3: Approaches for valuating opportunity costs of farm owned factors in selected countries/regions.**

| | ARMS (US) | 50 Sg report (Ukraine) | FADN (EU) | Observatory Arvalis-Unigrains | CONAB | Agri benchmark |
|---|---|---|---|---|---|---|
| **Family labour** | Off-farm wage | Family labour cost not taken into account | Regional agricultural wage of paid agricultural labour | Regional hourly cost calculated for valuation of family labour. An active full-time family worker is equivalent to 1600 h / year. | Off-farm wage | Off-farm wage |
| **Farm owned land** | Average cash rental rate by commodity and region | Not taken into account (99% of land is rented) | Land rental price for land renting on the same farm. If no rented land on farm, the average rent for the region and production specialization | Land rental price for land renting on the same farm | | Regional rental price |
| **Farm owned capital** | Long-term interest rate for farm assets; short term interest rate on operation capital | Accounting value of interest payments and equity costs | Real interest rate for farm assets | Charges on operation capital, machine and building | Long term interest rate | Long-term interest rate for machinery and buildings; short term interest rate on operation capital |

Sources: Garnier (2012); Mishra (2012); USDA-ERS (2012a), European Commission (2013)

## 3.5 How to allocate overheads and joint costs

CoP expenditure on multiple farm activities (e.g. commodities) is common in agriculture, as most farms operate several activities in a given period. Several inputs (e.g. capital, labour) may be shared among different farm activities resulting in joint costs. This concerns mostly indirect CoP which is not identified with a particular farm activity. Direct costs can be relatively straightforwardly associated with a specific activity.

According to AAEA (2000), joint costs may arise for three reasons: (1) expenses incurred for farm activities using a joint technology (e.g. allocation of pasture costs to a calf and cow), (2) expenses for inputs that affect more than one farm activity with non-joint technology (e.g. capital related expenses), and (3) expenses for production inputs that are either purchased for the farm as a whole or are used for all production activities undertaken by the farm (e.g. overheads). AAEA (2000) recommends that the allocation of joint inputs should be based on objective criteria reflecting information on input allocations and input levels. If appropriate criteria cannot be identified, the allocation of these costs to specific farm activities should be excluded.

In practice, different allocation techniques are used to allocate joint costs to specific farm activities, and allocation techniques vary by country and method. The two main determinants for the choice of allocation technique are the type of costs to be allocated and the type of data collected. Some cost types may require simpler allocation formulae than others depending on their inter-linkage with different farm activities. The type of data collected strongly determines how particular costs can be allocated. For example, the collection of supporting data (e.g. machine hours allocated to different farm activities, input quantities per activity), may significantly improve the allocation of CoP. AAEA (2000) lists commonly used allocation techniques:

- Machinery costs (e.g. capital recovery of machinery investment, fuel, lubricants, and repairs): One commonly used method for allocating machinery costs per activity is based on the number of hectares and number of machinery practices used by a particular activity. A second approach often used is based on engineering formulas. However, when machinery are activity specific (e.g., potato harvester), there is no need to apply allocation formulae but the associated machinery costs can be allocated to the respective farm activity.

- Buildings (e.g. costs of depreciation, interest, maintenance): For buildings used for a specific activity, their associated costs should be allocated to the respective activity. Costs of buildings used to house or

repair machinery should be allocated on the same basis as the costs of machinery which utilize these facilities.

- Labour: Allocation of labour costs depends on its use. For example, labour costs associated with operating or maintaining machinery should be allocated using the same basis as used in the allocating machinery costs. Labour costs incurred for a specific activity, should be allocated to that respective activity.

- General farm overhead (e.g. accounting and legal fees, general farm liability insurance, otherwise non-allocated labour costs, utilities): Methods often used to allocate these costs are based on the gross value of farm production or on the basis of other allocated costs.

The methodology for cost allocation to estimate commodity costs in ARMS (USA) is summarised in Table 4. In ARMS, direct costs (e.g. fertilizer and chemicals, feed) are collected per commodity directly from farmers and thus do not require an allocation technique to be applied (i.e. direct costing). Certain inputs for which monetary transactions are not available (e.g. home-grown seed and feed) are distributed based on similar approaches as are direct costs. However, to obtain their monetary value, survey data on physical quantities are combined with secondary data on input prices. The allocation of indirect costs is based on the combination of survey information on production practices, technical information on machine performance, and engineering formulas determined from machinery tests. These costs are computed for tractors, trucks, field machinery, irrigation and drying equipment used in crop production, as well as housing, feed storage, and manure handling equipment used in livestock production. The allocation of whole-farm expenses to specific commodities is based on their share of the total farm operating margin (value of production less operating costs) (USDA-ERS 2012a).

The agri benchmark uses a top-down approach for cost allocation. First, total costs are split in commodity direct costs and in whole-farm costs or costs incurred for multiple commodities. The whole farm costs/ costs incurred for multiple commodities are split to commodities based on technical coefficients (e.g. labour/machinery hours) or return shares. Fixed costs such as labour costs and machinery are allocated either by a direct costing method (when data available by commodity), by using technical coefficients, or by return shares. Overhead costs are allocated based on return shares. Direct costs (e.g. fertilizers, feed) are allocated to the commodity on which they have been spent (agri benchmark 2011).[19]

[19] The IFCN uses a similar approach.

In CONAB (Brazil), the cost values per commodity are obtained by multiplying the matrix of technical coefficients by the vector of factor prices. Technical coefficients are established by the panel of experts composed of CONAB experts, farmers, trade unions, academics, representatives from financial institutions, input suppliers and other relevant agents. Secondary data sources are also used (particularly for input prices) to complement the data collected through the panel meetings (CONAB 2010).

The ARMS, the agri benchmark and CONAB rely on a significant amount of cost and cost related data (e.g. technical coefficients) collected through surveys at commodity level or obtained from experts or secondary sources. A different approach is followed by the FADN (EU). The CoP data collected under the FADN are aggregated at the farm level and are not disaggregated per commodity (including direct costs). This requires application of an allocation technique for all cost types covered by FADN. The European Commission has developed several models to estimate CoP for different commodities: arable crops, milk and beef, and permanent crops. These models allocate farm costs to specific commodities based on the output shares for crop commodities and livestock units for animal products (European Commission 2013). On the other hand, the FACEPA (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture) has developed allocation techniques based econometric tools to calculate the FADN production costs for specific agricultural commodities (FACEPA 2011).

**Table 4: Approaches used to estimate commodity costs in ARMS (US).**

| Direct costing | Valuing input quantities | Indirect costing | Allocating whole-farm expenses |
|---|---|---|---|
| | ***Crop commodities*** | | |
| Purchased seed | Home-grown seed | Fuel, lube, & electric | General farm overhead |
| Fertilizer | Manure | Repairs | Taxes and insurance |
| Chemicals | Unpaid labour | Capital recovery | |
| Custom operations | Land | | |
| Hired labour | Operating interest | | |
| Purchased water | Ginning | | |
| | ***Livestock commodities*** | | |
| Purchased feed | Home-grown feed | Capital recovery | General farm overhead |
| Feeder animals | Grazed feed | | Taxes and insurance |
| Vet & medicine | Unpaid labour | | |
| Bedding and litter | Land | | |
| Marketing | Operating interest | | |
| Custom services | | | |
| Fuel, lube & electric | | | |
| Repairs | | | |

Sources: USDA-ERS (2012a)

## *Recommendations*

A recommended best approach would be to collect as many cost positions as possible at the considered unit of observation (e.g. at commodity level). Joint costs should be allocated to the unit of observation based on objective criteria. The data collected through surveys can be supplemented by various technical information (e.g. machinery performance) and additional supporting secondary data (e.g. input prices) to be used for allocation of joint costs. However, if objective criteria are not available, joint costs should be excluded and should remain unallocated.

# 4

# Usual obstacles to CoP international comparisons

In this section we illustrate the methodological and practical issues that may emerge when conducting international comparisons of CoP. We focus, but not exclusively, in more detail on four dairy studies to show that even for a given commodity, CoP methodologies can diverge within and across countries: (i) the 2011 dairy report from IFCN; (ii) the study carried out by the Kenya Smallholder Dairy Project (SDP), a R&D project jointly implemented by the Ministry of Livestock and Fisheries Development (MoLFD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI) (quoted as "Staal *et al.* 2003"); (iii) the study of Wambugu *et al*. (2011) from the Egerton University (Kenya), which assesses the economic performance of small-scale Kenyan dairy enterprises at farm level; and (iv) a dynamic analysis of costs, returns and profitability of cooperative and non-cooperative dairy farmers in West Bengal (India) done by Sarker and Ghosh (2008). The aim is to deliberately select a variety of approaches in order to highlight their corresponding advantages and drawbacks, and to show that at the time of implementing CoP systems, national statistic services are facing a broad range of choices.

The analysis of four studies related to milk production costs in the IFCN, Kenya and West Bengal (India) stress the difficulty to elaborate cross country comparisons even for a similar commodity (Ronzon 2013). Garnier went to similar conclusions when analysing CoP for cereals and arable crops in the USA (ARMS), Ukraine (50-sg report method), Canada (Top Management/TopWin), the agri benchmark method, Europe (FADN) and France (Arvalis-Unigrains Observatory) (Garnier 2012). Indeed, CoP data are far from equivalent in terms of (i) final product definition; (ii) cost component calculation; and (iii) time of collection.

***Final product definition***

- Same definition of the product: In the case of the milk production, the final quality of the milk (fat, content and germs) is highly dependent on technical practices (feeding), genetic management (breed), etc. Hence,

milk quality is, per se, the result of farmers' CoP choices. Comparisons of cost of milk production need to be done, all things being equal, for the same quality of milk. This issue is addressed by the IFCN by adjusting the fat and protein content to standard energy corrected milk (ECM). The same caution should be given for other commodities with different market channels (ie paddy vs. rice, sweet corn vs. fodder corn, etc.).

- Same cost unit: It is obvious that comparisons must be established according to the same unit. Nevertheless, this issue is more complex than it seems. In the four studies reviewed for milk production in Asian and Sub-Saharan African countries, four different units were used, hampering comparison: USD/100kg milk (ECM) in Hemme (2011), Ksh/L in Staal *et al*. (2003), Ksh/lactating cow/month in Wambugu *et al*. (2011) and Rs/day/cow in Sarker and Ghosh (2008). Moreover, sources usually do not indicate if they release cost per litre of milk produced, per litre of milk sold, or even per litre of gross milk or standard milk. This is why explanatory notes are of foremost importance to associate technical precision with the dissemination of CoP data. Finally, in some cases, unit divergences can be solved by converting all data in a common unit, particularly in the case of divergences in currency unit. But here again, the AAEA (2000) calls for caution in selecting the exchange rate: "There is often more than one exchange rate – an official exchange rate (some countries may have more than one official rate), and a black market exchange rate".

- Same terminology: In the same line as a call for a clear definition of the unit used, it is important to clearly define the terminology used. What does "cost of milk production" means? For example, the IFCN Dairy report 2011 differentiates the cost of "milk production only" (full economic costs minus the non-milk returns) from the "full cost" of the dairy enterprise. In other studies it is not always clear whether CoP refers to the costs of the single dairy enterprise or to the whole farm costs of farming systems specialized in dairy production. But the global literature on CoP offers even more confusing situations. An example is the term of "gross margin" that refers to "the difference between the value of gross output and variable costs" in UK, and that refers to "the excess of total revenue over the cost of the goods sold" in Canada (AAEA 2000). Some effort could be made to share a common list of cost components at the international level to allow for a detailed

comparison of physical input costs, human labour costs, etc. Whereas these costs components should be harmonized at the international level, they should also allow for flexibility in their disaggregation to account for national specificities. For example, animal labour can be an important cost item in some low and middle income countries while non-existent in the vast majority of high income countries' holdings. Conversely, insurance and subsidies can be irrelevant in some low and middle income countries while significant in high income countries.

***Cost component calculation***

First, concerning cost classification, "The distinction between cash and non-cash costs is of significance particularly in the context of developing countries where majority of farmers are small farmers (…) Non-cash costs account for a substantial portion of the total cost in developing countries" (CSO 2005). But at the same time, the classification into operating and overheads costs (and to a less extent into variable and fixed costs) is more common among high-income countries. In this regard, it is not worthwhile to change the whole cost item classification of survey datasets since the chosen classification makes sense in its specific context, and it may have been established decades ago. But a minimum requirement would be to provide a clear definition of each cost item allowing for its re-classification into another type of cost concept when, for example, inter-country comparisons are conducted.

Then, regarding cost calculation, comparability of CoP relies on harmonized cost concepts and similar rules of calculation and allocation. Even when total costs cover similar cost items like direct and indirect costs at the holding level, cost break-ups are divergent from one country to another. Some countries release total cost together with the main cost components, while others like India and Mauritius have defined their own cost concepts. In Mauritius, three cost concepts are proposed, from the single direct costs to total costs including or not family labour costs. In India, there are seven different cost concepts that correspond to different combinations of costs associated with owned factors of production (labour, land, capital) added to other remaining costs. Such a break-up allows for the assessment of the contribution of production factor cost into total costs and provides detailed information for the design of public policies oriented to one or several specific factor of production. In addition, in the Philippines, CoP are associated with performance indicators like "Returns above cash costs", "Returns above cash and non-cash costs", "Net returns" and "Net profit".

When total costs are not equivalent by definition, one alternative could be to compare costs item by item. But a same cost item can be computed according to different rules. The unpaid family labour item is generally the trickiest. For example, it is valued at the wage rate of a qualified worker in the IFCN Dairy

Report 2011 while Staal *et al*. (2003) prefer estimating it at 80% of the reported rural wage to account for fluctuating off-farm employment opportunities. Even when using standard operating procedures, context specific situations can lead to adoption of different bases of calculation from one case to another. This is why, following the same IFCN methodology, Garcia *et al*. (2006) value family labour cost at the wage rate of a qualified worker in Vietnam while the individual opportunity wage level is used in India and Pakistan in FAO (2010), and the average regional rate for a casual worker is used by Ndambi (2009) in South Africa, Uganda, Morocco and Cameroon.

In the same manner, allocation rules of joint costs and overhead costs differ from one study to another (refer to sections: "How to value farm owned factor of production" and "How to allocate overheads and joint costs"). Even the IFCN framework does not specify harmonized allocation rules for the milk enterprise: choices are left to the judgment of IFCN partners based on individual contexts. Nevertheless, they represent a crucial issue in developing countries, where farming systems embed multiple activities, to such extent that different crops and livestock can be produced on the same plot. The most common alternatives to allocating joint costs is to distribute them according to physical ratios (area or number of livestock heads of the corresponding enterprise) or according to economic results (share of gross margin, share of total value of output, etc. of the corresponding enterprise).

Finally, Asian and Sub-Saharan African countries are used to facing high fluctuations in meteorology and hydrology, which induce dispersion and variability in CoP (especially related to variation in yield, input purchase prices and output selling prices). On this topic, Garnier comments that "the consideration of risk, and particularly of the variability of production costs in general, is not sufficiently developed in production cost comparisons" (Garnier 2012).

"There is a plethora of methods for CoP calculation and it would be unrealistic to pretend that one is the best and that it can fit to all situations and address all concerns. The best method would then be the one used by the greatest number of people since the main interest of CoP is to allow for comparisons" (Reuillon, Fagon *et al*. 2012).

### *Time of collection*

Theoretically, data collected in different points in time should be made comparable by applying a discount rate. But, in "real" life, the discount rate cannot account for changes in CoP structure that occurred between the two dates compared.
When returns or profitability are of concern, the market price is related to the timing of production, as in the case of the selling of seasonal and off-season products proceeding from the Northern or Southern hemisphere (AAEA 2000;

Langrell *et al*. 2012). As a result, a six month lag can induce strong variations in returns/profitability data which cannot be methodologically offset. For transparency and understanding of results, such a situation should be mentioned along with quantitative data.

Inflation is a crucial issue because of the time lag between expenses and receipts (sometimes more than six months: spring to summer, not to mention multi-year enterprises). In countries with high inflation and great seasonal price fluctuations, prices should, in theory, be corrected for inflation to a common point in time. The same kind of consideration can be drawn for countries with high exchange rate fluctuations (say to the dollar), as the choice of the exchange rate when converting data to a common currency can greatly impact on the results (AAEA 2000; Langrell *et al*. 2012).

**Table 5. Rules for the Calculation of Cost of Milk Production in four case studies**

| | Hemme 2011 | Staal *et al*. (2003) | Wambugu *et al*. (2011) | Sarker and Gosh (2008) |
|---|---|---|---|---|
| **Family Labour** | Wage rate per hour for a qualified full-time worker in the region. | 80% of the reported cashed rural wage in the area. | Not included | Prevailing market wage rate of casual labour in selected villages . |
| **Own land** | Regional rent price.<br>In case of limited rental market, the land market value is capitalized at 3.5% annual interest. | Valued at the full reported rental rate. Land used for pasture or fodder is excluded (reflected in the cost for own-produced forage). | Not included | On the basis of prevailing rents in the village for identical types of land. |
| **Capital** | Circulating capital evaluated at 10% of all dairy related variable expenses.<br>Borrowed funds are capitalized at 6% real interest rate in all countries.<br>Own capital is capitalized at 3% real interest rate in all countries. | Opportunity cost or capital recovery cost, using the mean bank interest rate on saving (4,5%) over the useful life of the fixed input. | Not included | Interest on capital evaluated at the annual rate of 10% on the present value of assets.<br>Interest on working capital not valued. |
| **Depreciation** | Straight-line schedule on purchase price with a residual values of zero. | - | - | Straight line method on the lifetime of the asset, taking into account its residual value.<br>10% depreciation charged for cows in 4th and 5th lactation, 20% for cows in 6th and above lactation. |
| **Own produced manure** | - | Not included (represents additional revenue to the farm as an intermediate input). | Cost of hired labour and purchased inputs used in its production. | Market prices equivalent. |

***Recommendations***

*"The need for a uniform methodology for cost of production surveys has arisen due to the changes taking place at global level. (…) However, due to lack of adoption of uniform methodology in the process of data collection, inter-country comparison of cost data is still a constraint" (CSO 2005).*

International comparisons would ideally require a minimum harmonization of the terminology used, the cost concepts calculated as well as their rules for calculation and allocation, the calendar for collecting similar crops for the same crop year, etc. (FAO 2011; Friends of Chair on Integrated Economics Statistics 2012). Such cooperation is quite impossible to achieve in real life, nor is it desired by countries since it would require huge and often costly transformations of their national statistic systems. Nevertheless, some basic measures could be adopted at minimal cost to facilitate users' utilization of CoP data. This could start by the glossaries of concepts20 to accompany released data. Such tools are indeed of foremost importance to understand which kind of cost items are covered by a given survey and if CoP estimates can be compared with other sources or not. They would also help the re-aggregation of cost items to favour item by item comparisons. A following step would be to harmonize cost concepts as recommended by the FAO expert group meeting on cost of production and price (FAO 2011). But this will constitute a real challenge view the heterogeneity of cost concepts in use only among the few case studies presented in this working paper.

Besides, ideally, common methods of measurement/calculation would allow easier cross-country comparisons. Cash-costs are generally valued at their purchase price and it is common to estimate payments in kind at their market price at the time the payment in kind was undertaken. Harmonization of valuation rules for imputed costs is more challenging since one option can be relevant in one context and not in another. For instance, the valuation of farm owned land is often based on the prevailing rent at the local level for a similar type of land. But in some circumstances, the local land market is so thin that it hampers such methods of estimation. Thus it is more relevant to value the farm owned land on net land returns (Langrell *et al*. 2012).

[20] The glossaries, as a minimum should contain a concept label, definition, detailed source information and related terms (Friends of the Chair on Integrated Economic Statistics 2012).

# 5

# Conclusions

## 5.1 General comments

Previous sections provided a comprehensive comparison of methodologies and approaches for CoP data collection and processing as applied across developed and developing countries and at the international level. Gathering production costs is a complex process encompassing issues spanning from data collection design to selection, and development of methodologies for processing and analysing the gathered data.

Many developed and developing countries conduct their own collection of CoP data on production costs as part of a national agricultural data gathering exercise integrated in existing national surveys or as a stand-alone survey. However, in the vast majority of Sub-Saharan Africa and Asian countries there is no evidence of national systems for CoP data collection. When they exist, methodological approaches vary strongly in terms of collection approaches, the type of data collected, disaggregation of cost items, data processing, and the cost calculation methodology.

Indeed, in different regions of the world, very different concepts for the collection of farm-based CoP analysis have been developed and implemented, categorized by different criteria, including (but not exclusively): regional coverage (world-wide; national; regional; ad-hoc case studies), representativity (stratified sample; voluntary participation, representative farm), unit of analysis (whole farm data; commodity; plot level), frequency of data update (annually, multi-annually) and data collection method (delivery of bookkeeping data; interviews; mail, panel discussions). Further, intra-commodity variability with regard to differences in production systems, farm size, region, and management programs, as well as different business models (e.g. family based vs. hired-labour based farms) complicate data comparisons, and raise issues with regards of sampling size(s), technique, timing of data collection and cost accounting procedures.
It is important to note, that crop production appears to be over represented in CoP surveys in relation to livestock production. This is especially true in Sub-Saharan Africa and Asia where none of the surveys presented in this working

paper covers livestock production21. Experts from FAO confirm that "CoP studies are seldom conducted for livestock and products" (FAO 2005), while the IFCN global network tries to bridge the gap for dairy production. It is probable that livestock commodities are judged as less strategic than food crops. Nevertheless, their contribution to total agricultural production is significant, similar to vegetables, which are also poorly covered in CoP surveys (Surjit 2008). The same patterns appear also in developed countries, but the bias is much less evident as compared to countries in Sub-Saharan Africa and Asia.

There is a predominance across countries to collect and compile CoP commodity-wise rather than holding-wise because they provide critical indicators of the economic performance of different agricultural sectors, despite the fact that the former type of data are more demanding to collect and compile. In addition, methodological details on cost calculation and allocation rules are not always associated with CoP data, nor are they easy to access. This represents a real gap and hampers data analysis and cross-country comparisons, especially when dealing with multi-enterprise farming systems, double season cropping, and inter-cropping (which can be the majority of cases in Sub-Saharan African and Asian farming systems).

The delay in publication and the difficulty in disaggregating data are the first obstacles for use of national CoP datasets for policy purposes and in academic studies. Indeed, average CoP indicators are usually released for a given geographical area - country, state, agro-climatic zone, and the like - whatever the heterogeneity of farming systems in this area. Nawn (2013) mentions for India that "What makes these surveys unique is the fact that they collect plot-wise data on the crops grown in different seasons, the specific varieties used, irrigation source, sowing and harvesting dates, details of cultivation operations (including their timing and work inputs), and yields. Properly used, they can provide a rich source of material for better understanding of the nature and extent of diversity of agricultural economy, and their dynamics, across regions and across different types of farms and the factors underlying them. Unfortunately this potential has remained largely unutilized". Thus timeliness and access to detailed data would better inform policy makers and extension services as well as optimise the research function of such datasets (CSO 2005; Vaidyanathan 2005; Surjit 2008).

[21] For the livestock sector, methodological challenges for data collection include enumeration of nomadic and semi-nomadic livestock, social constraints to obtaining accurate numbers on livestock in pastoral societies and estimation of livestock products, especially with regards to small animals.

Finally, different "good practices" have been underlined throughout the report, presenting some advantage in either their respective context or to achieve a specific goal. In this sense, it is striking that CoP survey designs in Sub-Saharan African and Asian countries often had to cope with multiple constraints (see Box 1).

**Box 1. Facing multiple constraints: the art of operating trade-offs among Sub-Saharan African and Asian countries.**

In addition to their specific climatic, demographic and agricultural conditions mentioned in this working paper, Asian and Sub-Saharan African countries have almost all had to cope with strong budgetary constraints, limitations of highly skilled human resources, and even sometimes equipment limitations. They assess trade-offs according to the importance of such limitations and according to their specific national goals to adjust the frequency, geographical coverage, number of visits to holders and human staff according to the available resources.

In Zambia, specific efforts have been undertaken to favour the quantity and representativeness of data collected by sampling an impressive number of households in all country districts (more than 10,000 households for the maize survey). Such effort implies important expenses in human resources and could hamper the quality of the huge amount of data collected: indeed, the CFS relies on farmers' recall and estimations collected in a few visits without field checking.

The reverse approach is taken in India where half the number of households, compared to Zambian CFS households, is visited repeatedly during the whole cropping season in a selection of Indian States. Numerous visits to households favour more accurate data collection of crop items but, in the meantime, all Indian States are not covered and inferences cannot be performed at the national level. This choice makes sense in the Indian context where CoP surveys are aimed to inform pricing policies at the State level.

The Philippines seem to have opted for large commodity coverage at minimal price: conducting CoP surveys every three or five years in major producing provinces, but releasing continuous time series thanks to annually updated CoP estimates. Choices are not clear in the case of Sri Lanka where little information is available and in the case of Mauritius where only a one-shot survey has been conducted.

Another option to minimize the cost of data collection is to implement synergies with other datasets of the national statistical systems. In this perspective, operating costs (food, transport and fuel oil) in the Philippines CoP surveys are based on Consumer Price Indices, while farm gate prices like cost of seeds, irrigation fee, lease rental etc. are collected in the Farm Price Surveys (FPS), fertilizer prices proceed from the Weekly Cereals and Fertilizer Price Monitoring (WCFPM), and labour costs are based on the nominal wage from the Agricultural Labour Survey. At first sight, it can seem complicated to combine numerous data sources since it implies timeliness from all parties and strong cooperation among the services/teams in charge of the different surveys. But it is precisely because of this coordination that the Philippines are able to update crop CoP annually while conducting specific CoP surveys only every few years. In sum, it allows the release of continuous time series with minimized survey costs .

## 5.2 Specificities of Asian and Sub-Saharan African countries

It is worth remembering that the recommendations drawn throughout the report tend to fit with the large variety of country cases existing worldwide. Especially, it tries to take into account the main specificities of Asian and Sub-Saharan African countries, identified as follows:

- **Poor human and financial resources to allocate to CoP surveys.** The case studies presented in previous sections illustrate that financial and human constraints impact the implementation and functioning of national systems of CoP statistics. In the worst case, constraints are such that the country prefers not to implement any system of CoP data collection. In better cases, to lower the cost of data collection, trade-offs are to be made between sample representativity and data accuracy.

- **Reliability of administrative source.** In many Asian and Sub-Saharan African countries, administrative data present weaknesses and could introduce bias if used as data sources in CoP calculations. For instance, it has been argued that weak registration of non-land owners in India

resulted in the under-estimation of tenant farmers in CoP data when sampling was based on land registers (Surjit 2008). In other situations, combining field data with administrative sources on input prices, rental wages, etc. can be misleading because of local market malfunctioning or because of the importance of non-institutional markets.

- **Physical access to holding holders.** Holding dispersion and long distances tend to elevate the costs of data collection. Some areas in Asian and Sub-Saharan African countries are so remote that they are excluded from the sampling frame (NSSO 2005). Then heterogeneity in holding location complicates sampling design while the suppression of specific areas from the survey interferes with representativity.

- **Demographic characteristics of the holders.** A number of local languages are still in use in many Asian and Sub-Saharan African countries and farmers do not systematically speak/understand the official language(s). This matter of fact is a source of response bias (non-sampling errors) because of misunderstandings between farmers and enumerators. It also generates a new trade-off on whether to employ skilled enumerators (like researchers in Ethiopia) that manage quite well the questionnaire but sometime do not speak/understand well local language(s) or whether to employ local enumerators that can easily communicate with local farmers but at some point do not manage so well the CoP questionnaires. Ideally, questionnaires should be written and pre-tested in each local language in use. But once again, this generates extra-costs. Furthermore, FAO (2011) reported that illiteracy is an additional source of recall bias. The basic argument was that illiterate people cannot objectively document their costs (inability to fill up a farm record), nor calculate conversions between standard and local units of measurement.

- **Soil and climate conditions**. In tropical Asian and Sub-Saharan African countries, two cropping seasons are commonly practiced. Nevertheless, the cultivation of the same crop in different cropping season results in very different CoP because of seasonal fluctuations of input prices and different agricultural choices made (plot, fertilization, seed variety, etc.). This implies that CoP surveys concerning agricultural products cropped twice a year have to be doubled, generating extra-costs. Moreover, these regions are subject to highly varying meteorological conditions, including the occurrence of extreme weather events. This causes an

elevated inter-annual variability of yields (and by consequence of variable costs) and prices and it raises true conceptual questions in terms of CoP calculations and international comparisons. Policy makers and other analysts may be interested in yearly CoP to assess the impact of a particular event on agricultural production, but inter-annual averages could better help cross-country analyses and prevent comparisons based on an "unrepresentative year". The issue at stake is in reality: how to account for this kind of "structural variability" in international comparisons?

- **Production systems specificities**. Conversely to high income countries, a large part of Asian and Sub-Saharan African farmers use draught animals to work. This implies the inclusion of a specific cost item, animal labour (either hired or owned), and raises particular methodological questions. First, in case of owned animal labour, the same question arises as for unpaid family labour: how does one calculate its opportunity cost? By referring to the fee paid for an equivalent hired service? Or by referring to the cost of maintenance of the animal(s), taking into account the expected output from their selling or not?

  Secondly, concerning cropping systems, common practices in Asian and Sub-Saharan African countries are the mixed-crop and continuous farming systems, i.e. the cultivation of different crops in the same field and at the same time. This raises methodological questions far more complex than the simple issue of allocation rules for joint cost, since costs cannot be distributed according to the area criterion (the two or more crops are grown on the same land area). Distributing costs according to the share of total returns is not always relevant (one crop can be used for self-consumption and not sold), nor according to total production if the mixture can be sold/used as a whole (case of forage mixtures). One more difficulty occurs if one crop of the mixture is a leguminous, used to fertilize the other one(s): how does one value this fertilization function? Unfortunately, these questions are very poorly documented in the literature. Even in documents extensively detailing their methodology, issues related to mix-cropping are poorly addressed.

- **Changing economic contexts**. Some Asian and Sub-Saharan African countries high fluctuations of economic parameters that influence calculation and the resulting CoP. Indeed, inflation can be important, including for a short period of time, leading to great changes in input

prices between the beginning and the end of the cropping season. The use of prices corrected for inflation is then advisable when working on multi-year enterprises (tea, coconut, rubber, oil palm, etc.). Moreover, high input price elasticity induces an important inter-annual CoP variability. Fast variations in exchange rates are an additional issue when working on cross-country comparisons.

Locally, employment opportunities are also seasonal and/or fluctuating, which add complexity for the calculation of unpaid labour opportunity costs. Indeed, what was the probability for a farmer/family worker to gain an off-farm wage during the cropping season? Should we value his/her labour force at the full local average wage rate or at a percentage of it only, considering that he/she may have found a casual job only part of the year?

## 5.3 International comparisons of CoP: National data collection systems versus global networks

CoP international comparisons are gaining interest in the context of a globalizing world. They are unfortunately made difficult for a number of methodological reasons already stressed throughout this working paper, and have led to various international initiatives and propositions to build the ground of future CoP methodological harmonisation. This will not be an easy task and it will probably take time. We then want to conclude this working paper by pointing out that the first “strategic choice” governments will have to make is on whether to reorient their national data collection systems according to international rules, or to coordinate their efforts to feed global CoP networks.

Currently, most countries covered by this working paper conduct their own collection of data on CoP as part of a national agricultural data gathering exercise (Isermeyer 2012). As mentioned above, very different concepts for the collection of farm-based CoP analysis have been developed and implemented over the last number of decades.

An important advantage of the CoP data collected at the national level is that they can be tailored to address national users' needs. However, because methodologies vary strongly across countries, it is problematic to use them for inter-country comparison. The application of national CoP data sources for international comparison would require further data processing and/or harmonization of methodologies, but may not always lead to full cross-country comparable CoP values.

The agri benchmark and the IFCN based on the representative farm approach are the main data sources available for international comparison of CoP. They apply a common methodology for cost identification and calculation across all covered countries. They can be applied without further methodological adjustments to compare production costs among available commodities and regions. These approaches are based on networks of experts, advisors, panel of farmers and statisticians located in different parts of the world that collect and process data locally, and are coordinated by a central organization located in Germany (Isermeyer 2012). In fact, one of the main reasons why the RENAPRI network applies the common methodological approach of the agri benchmark in selected countries from East and Southern Africa is to be able to use the CoP data for inter-regional analysis (Jayne et al. 2013).

Both systems of CoP data collection have their own advantages and disadvantages. However, a crucial issue that should be considered in this context is the relevance of the comparability of CoP data across countries and users' needs in this respect. Experience shows that the implementation of CoP data collection systems at country level and un-coordinated across countries leads to limited international comparability of national level CoP data. To reduce this problem, international coordination is desirable to minimize the methodological differences between countries.

However, it must be recognised that full harmonization of CoP across countries may not be feasible from the implementation point of view. Countries might be deterred from implementing a harmonised methodology if the existing national system needs to be significantly adjusted or replaced by a new harmonised system. Existing national systems are often developed to address multiple policy objectives and are not solely designed to deliver CoP data. Redesigning the national system to improve CoP data collection may thus conflict with the collection of data used to address other policy objectives at the national level, thereby making this option highly unrealistic (Langrell, Ciaian and Gomez y Paloma 2012).

Current CoP data collection systems fully harmonised between countries are those implemented by global networks: IFCN and agri benchmark. The application of a common methodology across participating countries is ensured by a central organization which conducts the development of methodology and coordinates its implementation, whereas partner institutions located in participating countries conduct the actual collection of CoP data.

# References

**AAEA**. 2000. *Commodity Costs and Returns Estimation Handbook*. A Report of the AAEA Task Force on Commodity Costs and Returns (available at: ftp://ftp-fc.sc.egov.usda.gov/Economics/care/AAEA/PDF/AAEA%20Handbook.pdf).

**ADBG-AUC-FAO**. 2011. *Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development. An Action Plan for Africa 2011-2015* (available at http://www.fao.org/economic/ess/ess-capacity/ess-strategy/gs-publications/en/).

**agri benchmark**. 2011. *The agri benchmark network* (http://www.agribenchmark.org/home.html).

**agri benchmark**. 2013. *Analysis of cost, returns and profitability, agri benchmark* (available at http://www.agribenchmark.org/methods_cost_analysis.html).

**Bureau of Agricultural Statistics of the Philippines (BAS)**. 2013. *Metadata for National Agricultural Statistics of the Philippines*. Countrystat-Philippines webpage (available at http://countrystat.bas.gov.ph/?cont=2#).

**Burke, W.J., M. Hichaambwa, D. Banda, and T.S. Jayne**. 2011. *The Cost of Maize Production by Smallholder Farmers in Zambia*. Food Security Research Project No. 50. Lusaka, Zambia.

**Cesaro, L., S. Marongiu, F. Arfini, M. Donati, and M.G. Capelli**. 2008. *Cost of production. Definition and Concept*. FACEPA Deliverable D1.1. 2 (available at http://www2.ekon.slu.se/facepa/documents/Deliverable_D1-1-2_LEI.pdf).

**Cesaro, L. and S. Marongiu**. 2013. *The Use of Rica to Estimate the Cost of Production in Agriculture*.

**CONAB**. 2010. *Custos de Produção Agrícola: A metodologia da Conab. Companhia Nacional de Abastecimento* (available at http://www.conab.gov.br/OlalaCMS/uploads/arquivos/0086a569bafb14cebf87bd111936e115..pdf).

**CSO**. 2005. *Manual on Cost of Cultivation Surveys*. CSO-M-AG-02.

**European Commission**. 2013a. *EU beef farms report 2012 based on FADN data*. European Commission, Directorate-General for Agriculture and Rural

Development, Brussels (available at http://ec.europa.eu/agriculture/rica/pdf/sa502_beefreport.pdf).

**European Commission**. 2013b. *EU cereal farms report 2012 based on FADN data*. European Commission, Directorate-General for Agriculture and Rural Development, Brussels (available at http://ec.europa.eu/agriculture/rica/pdf/cereal_report_2012.pdf).

**FACEPA**. 2011. *Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture* (available at http://www2.ekon.slu.se/facepa/).

**FADN**. 2010. *Farm Accounting Data Network: An A to Z of methodology*. Version 4/11/2010, European Commission: Brussels (available at http://ec.europa.eu/agriculture/rica/pdf/site_en.pdf).

**FAO/APCAS**. 2008. *Metadata for National Agricultural Statistics - Sri Lanka*.

**FAO**. 2005. *A system of integrated agricultural censuses and surveys*. Volume 1 World Programme for the Census of Agriculture 2010. FAO Statistical Development Series 11. Rome, FAO.

**FAO**. 2010. *Status of and Prospects for Smallholder Milk Production - A Global Perspective*. by T. Hemme and J. Otte. Rome.

**FAO**. 2011. *Report from FAO Expert Group Meeting on Cost of Production and Prices*, Addis Ababa, Ethiopia, 28th to 29th November 2011.

**FAO**. 2013. *Statistical Reference Manual on Data Dissemination Using the CountrySTAT System (Revision 3).* Rome, Italy, FAO.

**Friends of the Chair on Integrated Economic Statistics**. 2012. Guidelines on integrated economic statistics.

**Garcia, O., T. Hemme, L.T. Nho and H.T. Tra**. 2006. *The economics of milk production in Hanoi, Vietnam, with particular emphasis on small-scale producers*. FAO-PPLPI working paper No 33.

**Garnier, J.F**. 2012. *Chapter 4. Production Cost Methodologies for Cereals and Arable Crops*. *In* Langrell, S., P. Ciaian, S. Gomez y Paloma, D.L. Cunningham, J.F. Garnier, F. Isermeyer and A.K. Mishra (2012). *Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies*. JRC Scientific and Policy Reports EUR 25436, European Commission, Joint Research Centre.

**Gitau, R**. 2013. *Results from the Typical Small Scale Farms in the Region: Kenya, Malawi, Mozambique, Tanzania, South Africa and Zambia - A*

*ReNAPRI Initiative Towards Comparative Regional Policy Analysis*. Paper presented at the 4th AAAE Conference, Hammamet, Tunisia. 24th September, 2013.

**Hemme T.** 2011. *IFCN Dairy Report 2011*. IFCN Dairy Research Center, Kiel, Germany, International Farm Comparison Network.

**Ismail, A., M. A. Simeh, and M.M. Noor**. 2003. *The production cost of oil palm fresh fruit bunches: the case of independent smallholders in Johor*. Oil Palm Industry Economic Journal 3(1): 1-7.

**Isermeyer, F**. 2011. "Global Comparison of Production Cost" Paper presented at the workshop on "Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies" European Commission, Brussels 21 - 22 June 2011.

**Isermeyer, F**. 2012. *Methodologies and Comparisons of Production Costs – a Global Overview*. *In* Langrell, S., P. Ciaian, S. Gomez y Paloma, D.L. Cunningham, J.F. Garnier, F. Isermeyer and A.K. Mishra (2012). *Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies*. JRC Scientific and Policy Reports EUR 25436, European Commission, Joint Research Centre.

**Jayne, T.S., T. Davis, R. Kachule, A. Akyoo, and R. Gitau**. 2013. *Comparative Cost of Maize Production Study in East and Southern Africa*. Paper presented at the 4th AAAE Conference, Hammamet, Tunisia. 24th September, 2013.

**Keita, N. and E. Carfagna**. 2010. *Overview of methodological issues for research to improve agricultural statistics in developing countries*.

**Langrell, S., P. Ciaian, S. Gomez y Paloma, D.L. Cunningham, J.F. Garnier, F. Isermeyer and A.K. Mishra**. 2012. *Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies*. JRC Scientific and Policy Reports EUR 25436, European Commission, Joint Research Centre.

**Langrell, S. P. Ciaian and S. Gomez y Paloma**. 2012. *Conclusions and Recommendations*. *In* Langrell, S., P. Ciaian, S. Gomez y Paloma, D.L. Cunningham, J.F. Garnier, F. Isermeyer and A.K. Mishra (2012). *Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies*. JRC Scientific and Policy Reports EUR 25436, European Commission, Joint Research Centre.

**Lys, P**. 2010. The Current State of Cost of Production Estimates - A review of Country Practices in Ethiopia, Mali and Zambia. Rome, Italy, FAO.

**Lys, P**. 2012. *Best practices on cost of production statistics – Friends of the Chair Recommendations for Cost of Production Surveys*. FAO Expert Group Meeting on Cost of Production Statistics. Dalat, Viet Nam, 5-6 October 2012. Rome, Italy, FAO.

**MACO/CSO**. 2009. *Zambia Panorama Report-Final*. GCP/GLO/208/BMG - CountrySTAT for Sub-Saharan Africa, Ministry of Agriculture of Zambia.

**MACO/CSO**. 2011. *2010/2011 Crop Forecast Survey Report*.

**Mehta, R**. 2011. *Statistics on Farmers and Farm Management for furthering synthesis of agricultural development and related policy analysis*. Paper for 4th Meeting of Wye City Group on Statistics on Rural Development and Agriculture Household Income , 9th – 11th November 2011, Brazil; Session 2: Statistics in Support of Sustainable Agricultural and Rural Development.

**Mishra, A.K.** 2011. *Opportunity Costs of Family Labour in the U.S*. Paper presented at the workshop on "Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies", European Commission, Brussels, 21-22 June 2011.

**Mishra, A.K.** 2012. *Chapter 5. Horizontal Technical Issues on Production Cost Methodologies*. *In* Langrell, S., P. Ciaian, S. Gomez y Paloma, D.L. Cunningham, J.F. Garnier, F. Isermeyer and A.K. Mishra (2012). *Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies*. JRC Scientific and Policy Reports EUR 25436, European Commission, Joint Research Centre.

**Ministry of Finance and Economic Development-CSO**. 2008. *Agricultural Cost of Production Survey 2005.*

**Nawn, N**. 2013. *Using Cost of Cultivation Survey Data*. Economic & Political Weekly Supplement XLVIII (26 & 27), pp 139-147.

**Ndambi, O. and T. Hemme**. 2009. *An economic comparison of typical dairy farming systems in South Africa, Morocco, Uganda and Cameroon*. Tropical Animal Health and Production 41(6), pp 979-994.

**NSSO**. 2005. *Access to Modern Technology for Farming*. NSS 59th Round (January–December 2003), National Sample Survey Organisation - Ministry of Statistics and Programme Implementation - Government of India.

**Ronzon. T.** 2013. *Literature Review on Cost of Production Methodologies Applied in Sub-Saharan Africa and Asia*. Unpublished manuscript.

**Reuillon, J.-L., J. Fagon, T. Charroin and M. Laurent**. 2012. *Coûts de production en élevage bovin lait*. Manuel de référence de la méthode proposée par l'Institut de l'Elevage, Institut de l'Elevage-FranceAgriMer.

**Sarker, D. and B. K. Ghosh**. 2008. *Economics of Milk Production in West Bengal: Evidence from Cooperative and non-cooperative Farms*. East-West Journal of Economics and Business XI(1&2), pp 132-152.

**Slaston. R.** 2011. *Methodologies and comparisons of Cost of Production: Ukraine*. Paper presented at the workshop on "Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies", European Commission, Brussels 21 - 22 June 2011.

**Shadbolt N.** 2011. *Methodologies and Comparisons- A global Overview: Methodologies as Applied in New Zealand*, Paper presented at the workshop on "Sustainability and production Costs in the Global Farming Sector: Comparative Analysis and Methodologies", European Commission, Brussels 21-22 June 2011.

**Sri Lanka-Department of Census and Statistics**. 2009. *Cost of Production of Paddy 1988*.

**Staal, S. J., M. Waithaka, L. Njoroge, D.M. Mwangi, D. Njubi, A.Wokabi**. 2003. *Costs of Milk Production in Kenya: Estimates from Liambu, Nakuru and Nyandarua districts*. SDP Research and Develpment Report No1 Samllholder Dairy (R&D) Project.

**Surjit, V**. 2008. *Evolution of the Study of Cost of Cultivation in India*. Paper presented at "Studying Village Economies in India: A Colloquium On Methodology, December 2008. Chalsa.

**Teixeira, W.S.** 2011. *Methodology Production Costs CONAB Brazil*. Paper presented at the workshop on "Sustainability and Production Costs in the Global Farming Sector: Comparative Analysis and Methodologies", European Commission, Brussels 21 - 22 June 2011.

**USDA-ERS**. 2012a. *Commodity Costs and Returns: Documentation*. Version: 1/10/2012, United States Department of Agriculture, Economic Research Service (available at http://www.ers.usda.gov/data-products/commodity-costs-and-returns/documentation.aspx).

**USDA-ERS**. 2012b. *ARMS Farm Financial and Crop Production Practices*. Version: 3/12/2012, United States Department of Agriculture, Economic Research Service (available at http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/documentation.aspx).

**Vaidyanathan, A.** 2005. *A Report on the Analysis of Data of Cost of Cultivation*

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