Agricultural Cost of Production Statistics in Africa: Methodological Approaches, Decisions and Challenges

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This article considers the methodology presented in the Handbook on Agricultural Cost of Production (AgCoP) Statistics prepared by the Food and Agriculture Organization of the United Nations (FAO), within the implementation of the Research Component of the *Global Strategy to Improve Agricultural and Rural Statistics*. This Global Strategy is an initiative endorsed by the United Nations Statistical Commission in 2010 and implemented in Africa through the *Action Plan for Improving Agricultural and Rural Statistics (from 2013-2018)*, developed by the African Development Bank (AfDB), Economic Commission for Africa of the United Nations (UNECA) and FAO, in collaboration with the African Union Commission (AUC). The Technical Assistance Component of the Action Plan was implemented by AfDB. From 2019 onward, AfDB has continued to provide technical assistance to its member countries in different areas of agricultural statistics, including AgCoP, within its Statistics Capacity Building Program.

This article identifies particular issues, challenges and perspectives related to the implementation of the AgCoP methodology in African countries, reflecting the experience and learning from bilateral technical assistance activities implemented by AfDB in African countries since 2013, as well as Regional Training Workshops on Agricultural Cost of Production Statistics conducted during the same period.

Keywords: Costs of production, agricultural surveys, modelling

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1. Introduction and context

The Global Strategy to Improve Agricultural and Rural Statistics (GSARS) was adopted in February 2010 by the United Nations Statistical Commission in response to the decline in the availability and quality of agricultural statistics in many countries and to meet the need for statistics to inform and support better decision-making in agriculture, addressing long-standing issues such as improvement of livelihoods of smallholders as well as more emerging topics, such as the relationship between agriculture and environment.

The main purpose of the GSARS is to provide a framework and methodology to improve the quality and availability of national and international food and agriculture statistics to guide policy analysis and decision making. The strategy aims at: (i) strengthening the statistical capacity of developing countries to produce reliable statistics on food security, sustainable agriculture and rural development; and, (ii) encouraging the formation of a long-term vision for the development of agricultural statistical systems in developing countries.

A regional action plan, '*Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development: an Action Plan for Africa 2011-2017*' was prepared by AfDB, FAO, and UNECA, in collaboration with the African Union Commission (AUC) to support the implementation of the GSARS in Africa. An accompanying paper[1] details the technical assistance delivery model used by the AfDB to implement the Technical Assistance (TA) component of the Action Plan and subsequent activities in Africa.

The Action Plan included research programmes to address methodological issues for improving the quality of agricultural and rural statistics, with the objective to produce scientifically sound and cost-effective methods that could be used as practical guidelines by country statisticians, training institutions and consultants, among others.

In international fora on agricultural statistics, information on Agricultural Costs of Production (AgCoP) emerged several times as one of the priority topics for developing countries. For example, participants to the 22nd African Commission on Agricultural Statistics (AFCAS 22, Nov. 2011, Addis Ababa) expressly requested that FAO, along with relevant organizations, undertakes research on this topic with the objective to provide a Handbook on best practices on AgCoP data collection, compilation and estimation.

In this context, the GSARS initiated research activities aimed at improving the availability and quality of data on AgCoP in developing countries. This work has led to the production of a *Handbook on Agricultural Cost of Production Statistics* providing practical and context-specific guidance for countries on cost-efficient ways to produce high-quality and internationally comparable AgCoP statistics. This publication benefited from the technical guidance of a group of experts from different national organizations with prior experience on this topic, such as the Economic Research Service of the United States Department of Agriculture (USDA), StatCanada and representatives from several National Statistical Offices (NSOs). The Handbook relates experiences from countries with existing programmes and findings from reviews of relevant academic and policy literature, together with results from in-country field tests and the feedback and experiences of countries. It acknowledges that countries differ with respect to their statistical infrastructure and their objectives, creating country-specific challenges. Several other documents on AgCoP have been produced under the GSARS, including a Literature Review, and field test reports provide additional resources including details on different country practices.

This paper does not seek to reproduce all the guidelines in the Handbook, but rather considers the particular issues, challenges, successes and constraints related to the implementation of the methodologies in African countries. This, in turn, reflects the presentations, deliberations, recommendations and conclusions from three African Regional Training Workshops on Agricultural Cost of Production Statistics. These were held in Hammamet, Tunisia, 7th-11th March 2016, for French-speaking counties; Cairo, Eqypt, 3rd-7th April 2016, for English-speaking countries; and Lilongwe, Malawi, 12th – 16th September 2023, for African Development Fund countries (both English and French speaking countries). This paper also draws on the experiences gained from the implementation of bilateral technical assistance programmes in several African countries, including Zambia, Lesotho, Malawi, Mali, Benin, Kenya, Zimbabwe, Tunisia, etc. A more detailed description of the achievements and outputs of the technical assistance programme in Malawi is given in an accompanying paper.

This article is structured as follows: after this introduction, Section 2 presents an overview of the process, approaches and challenges associated to the collection and compilation of statistics on agricultural costs of production. Then, Section 3 delves deeper into the valuation methods and procedures for the main cost items, presenting examples and

[1] *See paper titled "Building capacity of African countries to produce relevant Agricultural Statistics: Case of AfDB Technical Assistance Delivery Model".*

best practices from supported countries over the years. Section 4 focuses on the presentation and dissemination of information on Agricultural Costs of Production by African countries, in way that it is easy to analyse and use, a topic which is still presenting challenges to countries, and Section 5 concludes. The list of some of the main articles and documents referenced in this article is provided in Annex 1.

2. Agricultural Costs of Production Statistics: An overview of process, approaches and challenges

2.1. Definition

Following AAEA (2000), Agricultural Costs of Production is defined as the costs and returns associated with the production of a given commodity. AgCoP statistics therefore refer to the economic value of all the resources – inputs and factors of production, such as labour, land, and capital – that enter the production process of a given commodity, and all the revenues that are generated by that commodity. This definition implies that non-monetary costs and revenues should be covered, in addition to cash expenses and revenues received from commodity sales.

2.2. The institutional set-up

The AgCoP Handbook provides general guidelines for the compilation of AgCoP statistics across the very wide range of agricultural production systems in the world, acknowledging that there is no one definitive approach and that any methodology should reflect the context and specificities as regards the prevailing characteristics of the agricultural sector (e.g. prevalence of smallholders, etc.) and the experience in producing agricultural statistics in any given country. In that perspective, while the Handbook sketches a possible "gold standard", it also sets out appropriate alternative – and lighter – methodologies, with their relative strengths and weaknesses. Ultimately, each country needs to design and agree upon the methods to reflect its specific country-level conditions, the realities of the agricultural sector in the country, the experience of government organizations in collecting and compiling agricultural statistics and the user needs for AgCoP statistics.

Given the breadth of economic statistics in agriculture and the relative complexity in collecting data and compiling relevant indicators, countries wishing to develop an AgCoP statistics system would benefit from implementing a multi-disciplinary approach involving statisticians, agriculturalists, data processing experts, agricultural economists, policy developers and other users. Many countries have established a dedicated central group (e.g. Steering Committee / Task Force / Expert Group / Technical Working Group) to take responsibility for developing the AgCoP statistical system (e.g. in Lesotho and Malawi), while in others this responsibility has simply been added to existing working groups on agricultural statistics (e.g. in Mali and Zambia). Both options are relevant, provided that all relevant actors, both data producers and users, are involved in the process.

On this matter, interesting learnings can be drawn from the experience of several countries, within and beyond the African continent. In Tunisia and in Costa Rica, for example, private stakeholders have been involved from the onset, ensuring buy-in of farmer unions and producer organizations. Involving these actors also ensures that the data collection and processing tools adequately reflect the reality of the agricultural sector and its technical specificities (e.g. adequate level of granularity in data collection, good coverage of the main inputs, etc.), and offer a possibility to benchmark the results against other information sources (production costs are often measured by producer organisations).

2.3. Addressing the diversity of farming systems

The collection and analysis of economic data, and construction of related indicators, is relatively straightforward for farming systems based on mono-cropping (or single livestock herds), with uniform application of inputs, written records and with most inputs involving a procurement during the season. However, we know that these farming systems are not mainstreamed in the developing world, and especially in sub-Saharan Africa. Developing AgCoP statistics is much more complex in systems dominated by mixed cropping (and even more so for mixed stands of crops in the same field), non-uniform application of inputs, no written records and where some significant inputs such as the use of own land and labour have no simple cash equivalents. To assist with their decision making on methodological developments, countries, which participated in the different bilateral and/or regional training workshops conducted on AgCoP statistics, recommended that experiences and best practise should be shared through existing online platforms and the development of eLearning materials, tailored to the needs of developing countries. Participants also recommended the development and dissemination of a training 'toolkit' for the production, analysis, and dissemination of AgCoP statistics and that field tests undertaken in some

countries should be systematically published and made available to others.

The following sections emphasise some of the methodological issues that participants highlighted as particularly problematic, presenting examples of approaches tested and related results.

2.4. Accounting concepts and data coverage

An AgCoP statistical system is based on the conceptual framework of economic accounting, which suggests valuing, on the one hand, all the resources used to produce a given commodity and, on the other hand, the associated revenues. The quantity of each resource used in the reference season needs to be valued, whether the resource was fully or partially purchased during the season, retained from previous seasons, self-produced or received as a gift or donation. In order to compare production costs on a like-for-like basis, the resource used is valued at the prevailing unit price in the reference period whether purchased in the reference season or not, and whether a cash purchase was involved or not. Significant changes in prices during the reference period will affect the analysis (e.g. if prices are affected by high rates of inflation during the reference period) and it may be necessary to adjust prices for high inflation to a particular date in the season to ensure comparisons are on a like-for-like basis.

To estimate economic indicators, such as gross and net returns, production values need to be computed at the farm gate price. This may not be possible if a farmer sends or takes his product to a buyer. This selling price can be used for the AgCoP analysis, provided the transport costs from the farm to the buyer are also identified and reported separately in the table of results. Other transport costs should also be reported separately, e.g. to obtain inputs or to transport livestock. Similarly, any costs involved in preparing products for sale, beyond its harvested state or basic processing (e.g. cleaning, shelling, etc.), should not, in principle, be included in agricultural costs of production.

The accounting of costs and revenues covers a specific reference period: for crops, this will likely be the cropping season, acknowledging that there may be more than one cropping season per year reflecting the long/short rains or rainy/dry seasons, for example. For livestock, the reference period is likely to be the calendar year, or possibly any consecutive 12-month period (though the former is recommended). In all cases, the economic activities to be accounted for in AgCoP stop at the farm gate. As such, costs and revenues associated with processing, marketing, off-farm transportation, and storage (to the extent that it takes place off-farm) are not part of the scope of AgCoP data.

Table 1 below presents a list of the most common inputs and production factors used in the production process for a given commodity, and accounted for in AgCoP statistics.

Table 1
Examples of most common production factors and inputs, by commodity group

Crops	Livestock	Poultry
Seeds	Purchased fodder	Broilers / layers
Fertiliser	Feed concentrates	Bedding
Herbicides	Mineral salts	Feed
Transport to obtain inputs	Veterinary services	Water
Hired labour	Water	Medication
Hired animal use	A.I. & bull services	Cleaning & disinfecting
Hired machine/tractor use	Milking jelly	Transport to obtain Inputs
Land (rented)	Transport to obtain inputs	Heating
Family labour	Hired labour	Packaging for eggs
Own animal use	Slaughtering costs	Slaughtering costs
Own machine use	Repairs & maintenance	Hired labour
Own equipment use	Family labour	Repairs & maintenance
Own land use	Home grown fodder	Own labour
Utility bills/Taxes/Permits	Own building/equip. use	Own building/equip. use
	Utility bills/Taxes/Permits	Utility bills/Taxes/Permits

Source: Handbook on Agricultural Cost of Production Statistics (GSARS, 2016)

2.5. Maximizing data quality

2.5.1. Data quality management

The management of data quality is a necessary and vital component of any statistical programme, especially when it involves data collection on the field. This is especially true for AgCoP statistical systems in low and middle-income countries, which are characterized by a farming sector dominated by smallholders, with limited record-keeping practices

and, often, with low literacy levels. The issue of data quality is also critical for data collection on farm costs, because of the complexity and wide variety of production systems, inputs and resources used in agriculture. The main challenges related to data collection on costs include, but are not limited to: (i) The fact that information on quantities used of certain inputs is difficult to obtain (farmers may recall what they purchased, not necessarily what they used); (ii) Recall issues: e.g. purchases may be made early in the season and difficult to recall; (iii) Labour may come in different forms (e.g. exchange labour, family labour, external labour, etc.) and assessment of the time spent difficult to report (e.g. workers are often paid on a per-task basis); (iv) Data may be reported using a wide variety of non-standard units (e.g. bags, cribs, etc.), increasing the complexity and potential distortions associated with conversions to kg or other standard units.

In addition to all these data collection challenges, the computation of key cost indicators has been found to be highly sensitive to extreme values and outliers and, in general, to the quality of the underlying data. One of the reasons for this is the fact that overall sample sizes for economic or cost of production surveys are often lower than for standard farm surveys, and that estimations must often be done on relatively small sub-samples, to impute missing prices and values, for example.

Considering the above, as well as the experience from countries supported on this topic so far, a few recommendations can be made to maximise the quality of data on AgCoP[2]:

- Data quality controls and procedures must be included at all stages of the data production cycle: from the design of the questionnaire and formulation of questions, through on-site validation and up to post-survey data adjustments.
- It is also crucial to have dedicated personnel responsible for the data processing system, bringing together data processors / CAPI experts, statisticians and agricultural field staff who can provide information to set the consistency checks for data validation procedures (e.g. upper and lower bounds for fertiliser application rates by crop, etc.).
- Consideration should be given to starting on a small scale (a restricted number of commodities and small sample sizes) to build up experience and the development of the questionnaire and data processing system.

2.5.2. Dealing with non-standard units

The quantity of any input used, as well as that of any commodity produced, are often recorded in Non-Standard Units (NSUs), which can include bags of different size and volume, crates, cans, oxcarts and many others. The complexity is to determine the conversion factors to standard units, such as kg or tons, as the weight of NSUs may vary significantly depending on the commodity, region or even stage of the supply chain (e.g. a 50 kg maize bag at harvest may weight differently at the market, as the crop is drier and may have suffered losses, for example). The inaccurate conversion of these quantities into standard units (kg, litres, tonnes) can therefore distort AgCoP results, e.g. assuming a 50 kg fertiliser bag still weighs 50 kg when filled with another product, assuming an oxcart of manure is always 1,000 kg, etc. Where both the quantity of the input used and the quantity purchased are recorded in the same NSU, a unit cost for the NSU can be calculated, and the total cost of the input applied can be estimated. However, the use of NSUs puts limits on the use of the AgCoP data. For more detailed analysis, for example to 'normalise' costs to take into account the different sizes of farms or to build AgCoP models, it is necessary to convert all quantities to standard units. In this section, we suggest practical approaches to deal with NSUs both at the pre- and post-survey stages.

a) At the pre-survey stage

Questionnaires may be designed to better address the issue of NSU and conversions: asking respondents to provide answers in standard units can be an unfamiliar or difficult task for them and can introduce measurement error. Instead, allowing respondents to report quantities directly in NSUs is generally less of a burden on them, ultimately improving the accuracy of the information they provide.

This work, which can be time-consuming and costly, is critical in establishing a complete NSU library, that consists in[3]:

- A list of valid items and NSU combinations including condition and size options as appropriate e.g. Groundnuts, Pail (medium), Shelled; Sweet potato, Basket (large), Not applicable;

[2] *See more details on how the two first recommendations were implemented in the case of AgCoP in Malawi (Article titled "Development of AgCoP statistics system – The benefits of integrating CAPI technical capacity building: Malawi's experience").*

[3] *Adapted from Technical Note on Non-Standard Units (2021).*

- Location specific (e.g. regional or lower-level if appropriate) standard-unit conversion factors for all NSU combinations;
- A photo reference guide of the most common NSUs to standardize respondents' NSU reporting;
- Clear protocols and training materials for household survey teams to properly use reference photos during data collection;
- Clear and concise documentation on how conversion factors were collected and user protocols for data users.

b) At the post-survey stage

While conversion factors for NSUs should remain the gold standard, in their absence it may be possible to estimate quantities by using information from neighbouring households or by applying expert advice (levering extension services, for example). Examples of calculation processes are provided below:

- To estimate the quantity of seeds used, an average application rate (kg/ha) may be applied to the area planted;
- If 1 bucket of organic fertilizer costs 25 times more than 1 kg, then an estimate of the quantity the bucket holds would be 25 kg.

However, these techniques should be used as a last resort and only for a small minority of cases for each commodity. Again, by reducing the variability across farms, these methods have implications for any conclusion to be drawn from the AgCoP indicators.

3. Computing farm costs

3.1. Different types of costs

There are several ways to categorize costs, depending on the objective of the analysis. From a data collection and estimation perspective, an operational approach that has been recommended in most of the supported countries was to separate cash costs from non-cash costs. Cash costs can be defined as expenses in inputs that are typically purchased by the farmer, such as agricultural inputs (fertilisers, pesticides, etc.) as well as hired labour, among others. Non-cash costs refer to the economic value of the inputs or production factors that were used by the farmer, but that did not require a purchase. This is the case of inputs that are sourced from the farm itself (e.g. seeds, manure, forage, etc.), from the household (e.g. unpaid family work) or for which a value must be imputed for accounting consistency and comparability needs, such as opportunity costs for own land used for agricultural purposes or depreciation of farm assets. The figure below presents this simple but operational cost accounting framework:

Figure 1
Total costs and their decomposition

TOTAL COSTS		
Cash Costs	+	Non-cash Costs
• **Purchased inputs** (seed, fertiliser, pesticides, etc.) • **Hired labour** • **Hired services** (renting animals, machinery, etc.) • Overheads (fuel, taxes, electricity, etc.) • **Hired land**		• **Family labour** (opportunity cost) • **Depreciation** on owned machinery, farm buildings and equipment • **Farm-produced inputs** (seeds, feed, manure, etc.) • **Own land** (opportunity cost)

Source: Authors

In the rest of this Section, we will briefly present how these different components of total costs can be compiled or estimated, starting with cash costs.

3.2. Cash costs

3.2.1. Farm inputs

When a farmer uses an input in the season (e.g. a purchase of seed, fertilizer, pesticides, animal feed, or even external labour), its cost can be computed using the following formula:

*Cost of Input Used = Quantity used * Unit market price*

where both are measured in the same units (note: plant protection products can be acquired in pellet or concentrated form and applied in solution, leading to inconsistencies between the recording of the quantity used and the measurement of the unit market price). In the specific case of hired labour, the quantities used may refer to number of days or weeks, for example, and the unit price to daily or weekly wages. Using quantities of inputs used rather than quantities purchased ensures that we only value what is effectively used by the farmer during the season, ensuring an adequate measurement of productivity. Indeed, quantities used and purchased may differ, sometimes significantly, as part of the inputs may be retained for the next season, given away, stolen received as gifts or subsidies (the provision of inputs at a subsidised price or fully subsidised is a common practice in many low or middle-income countries, especially in sub-Saharan Africa). Fertilisers, pesticides or seeds, for example, may also be purchased in excess by farmers when prices are low and used during and after the season.

In terms of data collection requirements, 3 key pieces of information are needed to properly compute the cost of inputs: (i) the total quantity

used, (ii) the total purchase price or expense, and (iii) the total quantity purchased. The last two items are needed to adequately determine unit prices, which are then used in the valuation process. Recording the full details of the transaction is more likely to avoid the quoting of official or Government set prices and deals with the more complex purchasing arrangements, such as sharing of purchases and the identification of subsidised purchases. The total cost including any subsidy (e.g. the use of vouchers or coupons) should be recorded.

With this information, costs can be computed both net and gross of any subsidy, i.e. reflecting prices both at their full market price and after any subsidy. This allows to determine:

- Effective profitability (net or subsidised price);
- Economic profitability (market price) – necessary for cross-country comparisons; and
- Assess the magnitude and efficiency of subsidy schemes.

What if all or part of these inputs have not been purchased during the season, which may be the case for fully subsidised inputs, those received as gifts, or quantities retained from previous seasons, for example? To put a value on the use of these inputs, unit prices obtained from neighbouring farms with a purchase can be used. To limit the influence of extreme values, the use of median unit prices from neighbouring households is recommended, rather than the mean. For the estimation of current unit market prices to work well, these should be calculated over groups of farmers with similar characteristics, for example in terms of farm type, size and crop/activity mix. It is recommended that the calculation of median values should be based on groups with a minimum number of observations, reflecting the variability of the observations. Many national survey designs follow the country's administrative structure (e.g. village, district, region, state) and each dataset includes variables to identify the location of each farm within this structure. If sample sizes are too small or the responses too varied to produce reliable results at the lowest administrative level, it is usually computationally straightforward to calculate unit market prices for the next level up in the administrative structure. This approach removes some of the variability expected in costs between farmers, which needs to be considered when analysing AgCoP results.

3.2.2. Hired labour

The collection and computation of hired labour costs follows a similar approach like the one presented above (multiplying quantities used by a unit price), but has its specificities, as follows:

- The quantities used may refer to number of days or weeks, for example, and the price to daily or weekly wages. There needs to be a consistency between the unit used for time worked and the unit used for wage. For example, if the time spent is recorded in days, the unit wage should be a daily wage.
- For hired labour, there is no differentiation between quantities used and purchased, as workers are hired and paid for a certain amount of time or to conduct a given task during the season.
- It is also important to collect information on the quantity of hired labour used by the respondent, as the calculation of a unit wage (cost per hour, per day, per week, etc.) may be used in the valuation of unpaid family labour.
- Information on the cost of hired labour must include all cash payments and any payroll-related taxes, and social contributions (social security, pensions, etc..) plus in-kind payments (e.g. free meals, accommodation), valued at the market price. If a share of the output is given to the employee as payment, it should be valued using the farm-gate price and added to labour costs.

3.2.3. Hired services

The assessment costs for hired services (e.g. renting of machinery, equipment, animals) differs from the above in the sense that it is usually difficult to separate quantities and unit values. Rather, the total expenses are directly asked to the respondent and the values for the different services summed up to obtain the corresponding costs. Moreover, for services the difference between purchased and used amounts is not relevant, and hence asking only for purchases does not lead to incomplete or distorted results.

One of the difficulties in accounting for the specific costs in hired services relates to the fact that services often come in packages, where machinery and specialist equipment may come together with labour (e.g. tractor operator) and/or even inputs. This includes, for example, hiring machinery or draught animals with an operator, hiring specialists to provide the full service to apply fertiliser or pesticides (including the product and application equipment) and veterinary expenses. These expenses should be reported under service costs, and not under hired labour, which involves separately hiring and eventually contracting individuals to perform different tasks on the farm. When the cost to the farmer of the service provided is not available, it can be imputed from the values

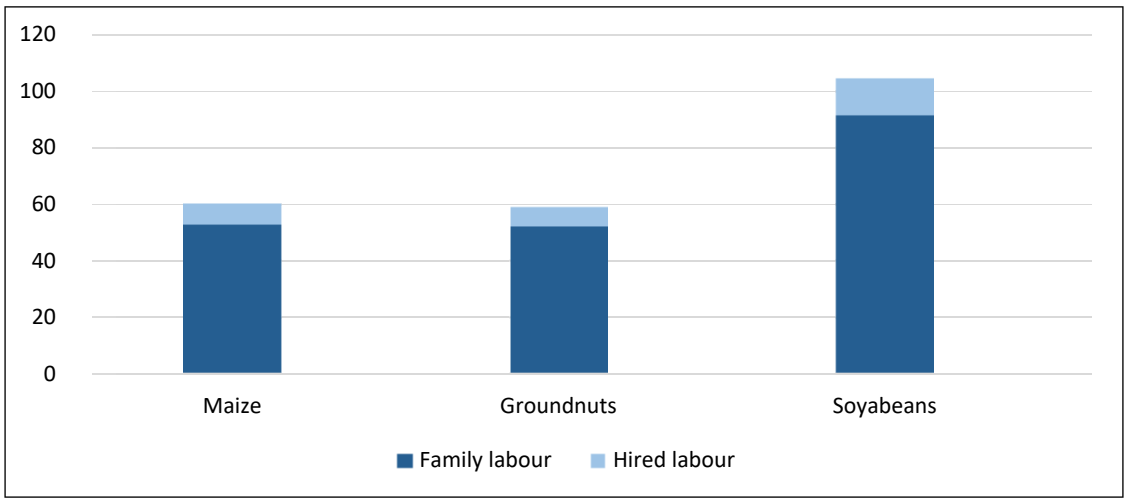
obtained from similar farms using an analogous approach than the one described above for other cash costs. In last resort, service costs can also be valued by costing each component separately, e.g. input, labour, etc.

3.3. Non-cash costs

3.3.1. Unpaid labour

In low and middle-income countries, unpaid labour -provided by household members- often represents the most important resource employed in agriculture. Presenting production costs with or without the evaluation of family labour makes a significant difference, and for this reason it is generally suggested to present total costs with and without imputed costs (in which unpaid labour is included) and to identify imputed costs for unpaid labour as a separate item in the cost table. An example of the importance of unpaid labour in sub-Saharan Africa is given in Figure 2, that presents results of labour intensity (number of days worked per hectare and year) by crop and type of labour in Zambia. These results are drawn from a pilot-survey on agricultural costs of production conducted under the GSARS in 2016-2017. Another illustration of the importance of unpaid household labour is given in Figure 3 that compares the importance of different types of labour in total labour costs in the Philippines.

Figure 2
Labour intensity by crop (in working days per hectare per year) in Zambia



Source: Authors, based on a pilot survey on agricultural cost of production (Zambia, 2016–2017)

Figure 3
Share of labour in total production costs for different crops (Philippines, 2012)

Source: Handbook on Agricultural Cost of Production Statistics (GSARS, 2016)

Unpaid family labour is provided by the farm operator and household members (this may include children with an age cut-off to reflect the legal and social context). The reporting of the time spent on agricultural activities can be captured in several ways: by combining factors such as by household, by individual members, by plot, by crop, by activity (ploughing, planting, weeding, harvesting etc.), and time. For example, the time spent may be captured for each plot and each individual household who contributed to each activity (ploughing, planting, etc.).

Unpaid labour, as the other inputs or factors or production that are self-supplied, should be valued at its opportunity cost (the benefit that may have accrued if household labour had been used elsewhere). The most straightforward way the opportunity cost can be imputed is by the amount of time family members spent on farming activities times the median unit wage paid to agricultural labourers hired in the locality (different unit wage rates can be used for men, women and children). This assumes that, in a unit of time, household members work is as productive as hired labour, which is disputable.

The relevance of this approach depends on whether hiring farm labour is common in the locality. If this is not the case, the suggested alternatives include using the average off-farm wages in the area or administrative information on official or minimum wages (the AgCoP Handbook also identifies sophisticated econometric methods based on age, gender and educational qualifications). As with other imputed costs, the value of family labour should be presented separately from cash costs in any AgCoP analysis and indicators aggregated and presented with and without imputed costs.

Measuring farm labour is, however, fraught with practical difficulties. With the informal nature of smallholder agriculture, working hours can be highly irregular, with periods of low labour activity after planting and prior to harvest. The reliance on weather in rain-fed agriculture leads to added unpredictability. These features can lead to difficulties for respondents when recalling how much time various members of the household worked on the farm.

The most common approach is to ask survey respondents to recall the amount of time each member of the household spent on farm activities during the previous agricultural season (end-of-season recall). Research has shown that end-of-season recall considerably overestimates farm labour inputs compared to weekly recording (though the amount of bias is itself variable – see Gaddis et al). Results from AgCoP field tests in Malawi and Zambia show that imputed costs of farm labour represent the most important component of total costs of production.

Considering the above, while more frequent visits may increase respondent fatigue and will put pressure on survey budgets, it is recommended that at least 2 visits are made per season to collect farm labour data.

To maximise data quality for this complex dimension of farm costs, it is also recommended to include consistency checks at the data collection, input, and validation phases. To facilitate this process, it is useful to establish the amount of time needed to complete specific activities by direct observation and timing, or from expert opinion or focus groups. This would set lower and upper bounds to the estimates provided be the respondents and, in case of missing or incorrect information, such 'normative' timings can also be used to impute time spent for the activities known to be carried out by household members.

3.3.2. Own land

Farmers may use their own land or hire land to conduct cropping activities or livestock grazing. In the latter case, the cost is simply the amount paid by the farmer (in-cash or in-kind) to hire the plot or field during the agricultural season. To obtain a complete picture of AgCoP, it is also required to value the land owned by the farmer and used for agricultural purposes, as this is a key input – such as household labour – that enters the production process. The reason for valuing the cost of own land is the same than for household labour: if all livelihoods are to be considered, all inputs and production factors must be accounted for as well. In alignment with the economic accounting principle, all costs and revenues should be valued, whether monetary or not. The same recommendations presented for unpaid labour in terms of dissemination of cost indicators apply to own land: total costs should be presented net and gross of imputed costs (which includes the economic value of own land), and costs of own land should be presented as a separate item in the final cost table, along with other imputed costs.

The valuation of the cost for own land can be difficult and not relevant in all contexts – e.g. when markets for land are thin or inexistent. For that reason, any approach should be considered and agreed by the steering committee / expert group in charge of overseeing the work on agricultural costs of production. Determining a unit value for land costs (e.g. cost per hectare per year) to impute costs for own land can be based on:

- The rental income of land known to be rented in the locality or region. However, while for commodities it may be safe to assume that, within a local area, the quality of the product is reasonably consistent, this may not be the case

for land. Rental rates are likely to vary depending on the quality of the land and its suitability for growing different crops. It can be impractical or highly complex to try to match land areas with similar characteristics to ensure that rental rates are valid, as these characteristics are not well defined and often missing from survey questionnaires (e.g. soil type or quality, etc.).

- The farmer's own estimate of how much rent he/she would expect to receive if the land was rented out for the season. However, it may also be that the renting of land is an example of a 'thin' market where only a small proportion of households rent their land, constraining the knowledge that farmers may use to provide an estimate.

Irrespective of the valuation method chosen, in cases were land rental or purchase markets are thin or inexistent in the locality where the survey is conducted, the opportunity cost may be considered to be low (the opportunity cost is defined as the value of the input in its next best alternative use) and could be set at zero.

Reflecting differences in contexts and production systems, practices adopted by countries tend to vary significantly. In the case of a cost of production survey conducted in Morocco, for example, the assumption made was that the opportunity cost of using a farmer's own land is equal to a third of the value of production from the land. This assumption was made because the actual rental market was small and rents highly volatile, preventing the determination of meaningful rental rates that could be used for imputation. Results were also disseminated with and without the imputed opportunity cost of a farmer using their own land, in line with recommendations.

3.3.3. Depreciation of farm assets

Capital is an important production factor in agriculture, along with labour and land, even though its weight in low and middle-income countries, which are still dominated by relatively small and household-led farms, is comparatively lower than in high-income countries. Nevertheless, capital costs must be accounted for in any AgCoP statistical system and analysis, in accordance with the principle that all the resources used to produce the commodity in the reference period need to be valued. Given the comparatively limited importance of capital assets for the farming sector in low and middle-income countries, which is the focus of this article, the valuation methods proposed below reflect a pragmatic approach that acknowledges the complexity in collecting data on capital assets for the small-scale agricultural sector.

The requirement to value capital assets stems from the fact that these assets have a lifetime of several years and that they must be replaced as they reach their respective end of service life to maintain the service level of the asset base of the farm. The AgCoP statistical system requires that a value is put on the use of capital assets during the cropping season or annual production cycle, even though they are used across many seasons or years. This value corresponds to the annual depreciation cost of the assets, which can also be interpreted as the cash amount that the farmer needs to set aside every year or season to replace the assets at the end of their service life.

Different types of capital assets can be defined according to their service life, cost and size. Consumer durables, such as hoes, axes, knifes, bags, etc. for example, are relatively small assets that tend to be comparatively less costly and with a shorter service life than more expensive assets such as farm buildings, machinery and equipment. To maximize the efficiency of data collection and considering the fragmented nature of farming systems in the developing world, we recommend that the valuation of capital costs focuses primarily on these large capital assets.

The most common approach to assess depreciation costs is the "straight-line" depreciation. If the purchase price and the service life of the asset is known, the depreciation cost per season or per year can be computed using the following formula:

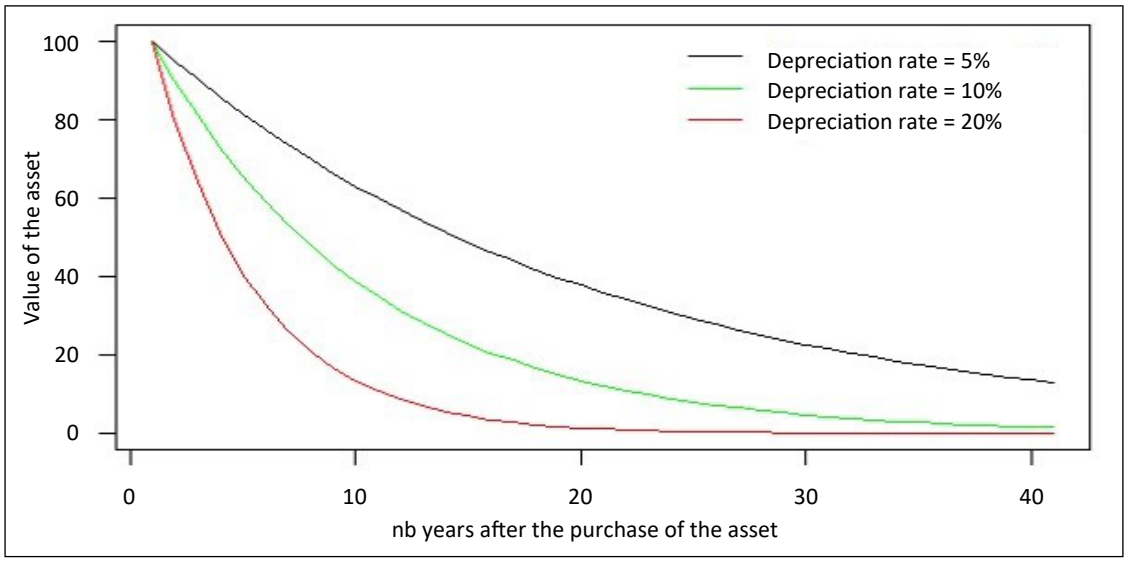
$$Depreciation\ costs(t) = \left[P(0) - P(T) \right] / T$$

where T is the useful service life of the asset, P(T) its price at the end of its service life (salvage value, which can be assumed to be 0, for simplicity), and P(0) the purchase price of the asset. This approach is easily understandable, though it is data demanding: it requires knowledge of the service life of the asset and of its purchase price, which can be difficult to recall for assets with long service life (20 or 30 years, for example), such as tractors or large equipment. Another limitation of this approach is the assumption that assets depreciate by the same fixed amount for each period, which is unrealistic given that assets tend to depreciate more when newer.

An alternative approach, known as the Declining Balance Approach, has often been recommended in the context of smallholder farming in low and middle-income countries: it consists in applying a fixed rate of depreciation to the current value of the asset, which can eventually be differentiated depending on the type of assets (e.g. 5% for large assets such as machinery, 20% for smaller equipment), as illustrated in Figure 4. While this

approach implies a more realistic depreciation schedule as the depreciation cost is greater when the asset is newer, the asset never fully depreciates to zero. In that perspective, this approach is likely to be more adapted to capital assets with a long service life, which as we suggest should be the priority when focusing on the small-scale sector. Also, while the current value of the asset can be estimated relatively easily by the farmer, there must be an agreement on the fixed rate of depreciation to be applied, and a relatively high degree of subjectivity can be expected in that process.

Figure 4
Depreciation schedule for the declining balance approach



Source: Authors

There are other costs associated with the use of capital assets, such as taxes, insurance fees, interest payments on loans, among others, that must be accounted for in the data collection instrument.

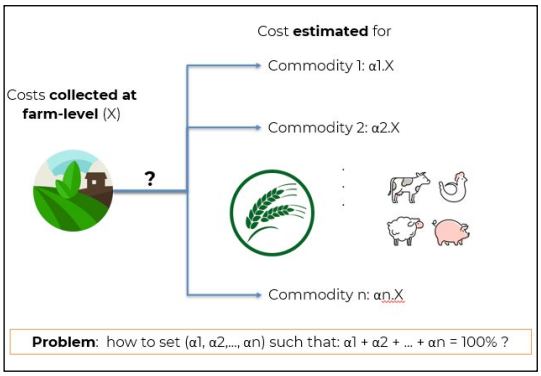
3.4. Allocating common costs to individual commodities

One of the main objectives of an AgCoP statistical system is to construct average cost and profitability indicators by activity (e.g. by crop, livestock activity, etc.). Crop-specific information on costs and revenues may not always be readily available, as data may be collected for a group of commodities or even for the farm or household as a whole, and that, for practical reasons, in order to minimize the burden on respondents and to shorten the questionnaire, and for conceptual reasons, when inputs or production factors are used in the production of more than one commodity; for example, when:

- Farm machinery and equipment, such as tractors, ploughers, or vehicles are used for many cropping or livestock activities;
- Two or more crops are grown in the same field, in an intercropped or mixed fashion (e.g. maize-groundnuts, maize-beans, etc.), making it complicated or even impossible to determine the quantity of inputs applied to each commodity (e.g. fertilisers applied to a field and not specifically to each commodity grown on it).

In this situation, if one of the objectives of the AgCoP statistical system is to produce consistent and comparable commodity-specific indicators on costs and revenues, allocating certain costs to individual commodities using an appropriate estimation method becomes necessary (see Figure 5).

Figure 5
Schematic visualisation of the allocation "problem"



Source: Authors

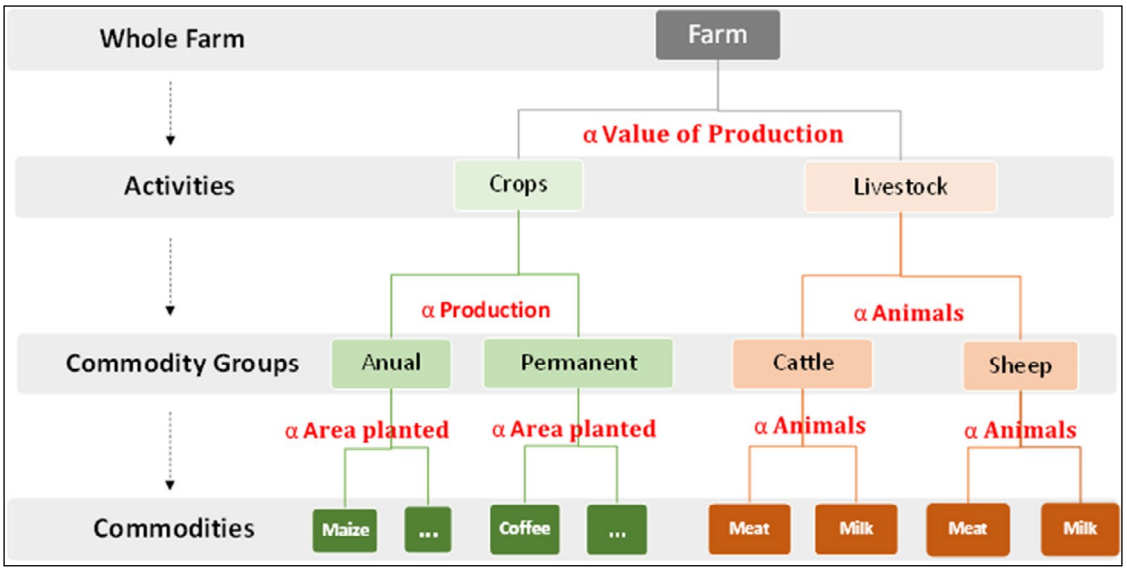
While the AgCoP Handbook provides best practice examples, allocation approaches vary widely in their complexity, level of detail and are highly context specific. For example, using an area-based allocation approach may work for some inputs (e.g. labour) but not for others (e.g. fertilisers), or for certain crops in specific contexts (e.g. if intercropped but not mixed etc.). The final decision must therefore be left to the implementation team - which is the closest to the realities of the field - and needs to be agreed between producers and users of the AgCoP analysis, that must also be aware about the limitations of each approach and the implications of the different allocation methods on the interpretation of the commodity-specific indicators (e.g. smoothing of differences across inputs on costs per hectare for certain crops, etc.). Two families of approaches have been suggested and tested by the GSARS over the years, and are presented below in some details:

- ***The "mechanistic" approach***: the cost of the input is systematically allocated across all the commodities involved according to a relative allocation rule e.g. by relative crop areas, value of production etc. While this approach has the advantage of being consistent and relatively easy to automate, the results may not adequately reflect reality.
- ***The "judgemental" approach***: this takes a case-by-case approach to each input being considered for allocation, based on the knowledge of the sector/production processes. The cost of inputs can be allocated to the commodities where they have most effect e.g. all fertiliser costs may be allocated to maize when grown in mixed stands, for example. While this approach more adequately reflects reality, it is more difficult to automate and requires a good knowledge of the use and application of inputs to specific crops.

A third approach, which is a blend between the first two, can be devised by determining context-specific systematic allocation rules that lend themselves to easy automation while reflecting more accurately the reality of the production processes than a unique systematic allocation rule. This blended rule, for example, may be differentiated depending on the input being allocated, the allocation stage (an example of blended approach is illustrated by Figure 6) and the type of commodity. A few examples are provided below:

- For equipment & machinery used in the production of several crops and/or livestock products, depreciation costs can be allocated to the different commodities on the basis of either time used for on each commodity, planted or harvested area (for crops), or animal heads for livestock. This methodology can also be applied to overhead costs, an area identified as a particular issue in the training workshops held for African countries.
- Labour costs can be allocated between commodities using labour intensity factors by task (days and weeks for each task), planted or harvested area (for crops), or animal heads for livestock.
- Costs in fertilisers and plant protection products may be allocation between commodities using crop-specific application rates, planted area or production quantity.

Figure 6
Example of "blended" allocation procedure



Source: Authors

4. Presenting and disseminating AgCoP statistics

Through the AgCoP technical assistance activities conducted by different partners, particularly AfDB and FAO, it has been evidenced that many African countries do collect, at least partially, information on farms costs and revenues, but that very few (if any) produce, analyse and disseminate meaningful statistical indicators that may be used by private or public decision-makers, and by the farmers themselves. The reasons for this are varied, ranging from the lack of resources to conduct analysis, the lack of technical capacity within NSOs or offices in charge of agricultural statistics, as well as the overall lack of understanding of the conceptual background underpinning farm economic analysis and its key indicators. This Section presents a brief introduction to data/indicators dissemination for AgCoP, focusing on user needs.

4.1. Total farm costs and their decomposition

There are many ways to group AgCoP, in order to simplify their presentations, produce sub totals and indicators. An approach, presented in Section 2.4, proposed to differentiate costs according to two dimensions: cash and non-cash costs. This distinction makes sense from a data collection and estimation perspective, but other categorizations may also be used for the purposes of disseminating data and catering to user needs.

An example of categorization is to divide total costs between variable and fixed costs. Variable costs are those that vary according to the quantities produced such as using more or less seed, fertiliser or labour. Fixed costs are those costs that can be considered independent - on the short to medium-term - from the quantities produced. This includes capital assets, such as equipment, machinery and buildings and other farm infrastructure; farm overheads such as taxes, license or certification fees, can also be considered as fixed costs. This categorisation into variable and fixed costs allows to map costs with decisions and choices that can be made for the next season (variable costs) and are therefore open to influence, and fixed costs which must be met whatever the decision in the short to medium term is. This distinction may not be too useful in farming systems where fixed costs are not significant or not of great interest for analysis, as this is typically the case in the agricultural sector of low-and middle-income countries. An example of economic indicators, reflecting the cash/non-cash costs distinction, is provided in Table 2 below.

Table 2
Costs of production and economic indicators

Mkw	Cash Costs	Imputed Costs	Total Costs	Production Value	Gross Return	Net Return
	(a)	(b)	(c)=(a)+(b)	(d)	(e)=(d)-(a)	(f)=(d)-(c)
Local Maize						
Per Grower	24,907	39,058	63,965	57,776	32,869	-6,190
Per acre	23,419	36,725	60,144	54,324	30,905	-5,820
Per 50kg production	3,025	4,744	7,770	7,018	3,992	-752
Hybrid Maize						
Per Grower	50,406	43,200	93,605	96,020	45,615	2,415
Per acre	44,802	38,397	83,199	85,346	40,544	2,147
Per 50kg production	3,708	3,178	6,886	7,064	3,356	178

Note: Mkw refers to Malawian Kwacha (Malawi's national currency).
Source: Authors analysis of Malawi 5th Integrated Household Survey 2019/20 (unweighted results).

4.2. Normalisation of indicators

As costs are proportional to production and size of establishment, cost indicators should be 'normalised' so that meaningful comparisons across different farms can be made. This creates additional data requirements, as data on the normalisation variable must be collected as well. Examples of normalisation approaches are provided below:

- Costs can be expressed by land area (planted or harvested) as per hectare or subsequent

multiples, such as 1000 ha, if this better reflects average farm size. The cost per unit of land area is likely to be more stable in the short term than per crop yields, which are more volatile.

- Costs per unit of production (per kg, per 50 kg or 50 kg bags, MT or 100MT) provides a more direct measure of the profitability of the farm. Production units may also be more meaningful for users. Presenting costs per production or selling units may require converting local units to standard units which, as we have seen in Section 2.5.2, may be challenging.
- For livestock, costs may be expressed per head, per 100 or 1000 head, per animal live weight or a weight that is closer to the average animal weight. Similarly, for livestock products, such as the cost per 1000 litres of fresh milk or the cost of producing 100 eggs.

The following table shows how the normalisation of costs can be used to present AgCoP results.

Table 3
Normalised cost of production results

Mkw	Local Maize		
	Per Grower	Per acre	Per 50kg
Seeds	2,718	2,556	330
Inorganic fertiliser	17,747	16,686	2,156
Organic feriliser	889	836	108
Plant protect. Products	159	150	19
Hired labour	2,269	2,133	276
Agric. Services	67	63	8
Land rent	588	553	71
Transport	470	442	57
Total Cash Expenditures	**24,907**	**23,419**	**3,025**
Own land use	13,192	12,404	1,602
Family labour	23,874	22,447	2,900
Depreciation	1,993	1,874	242
Total Imputed Costs	**39,059**	**36,725**	**4,744**
Total Costs	**63,965**	**60,144**	**7,770**

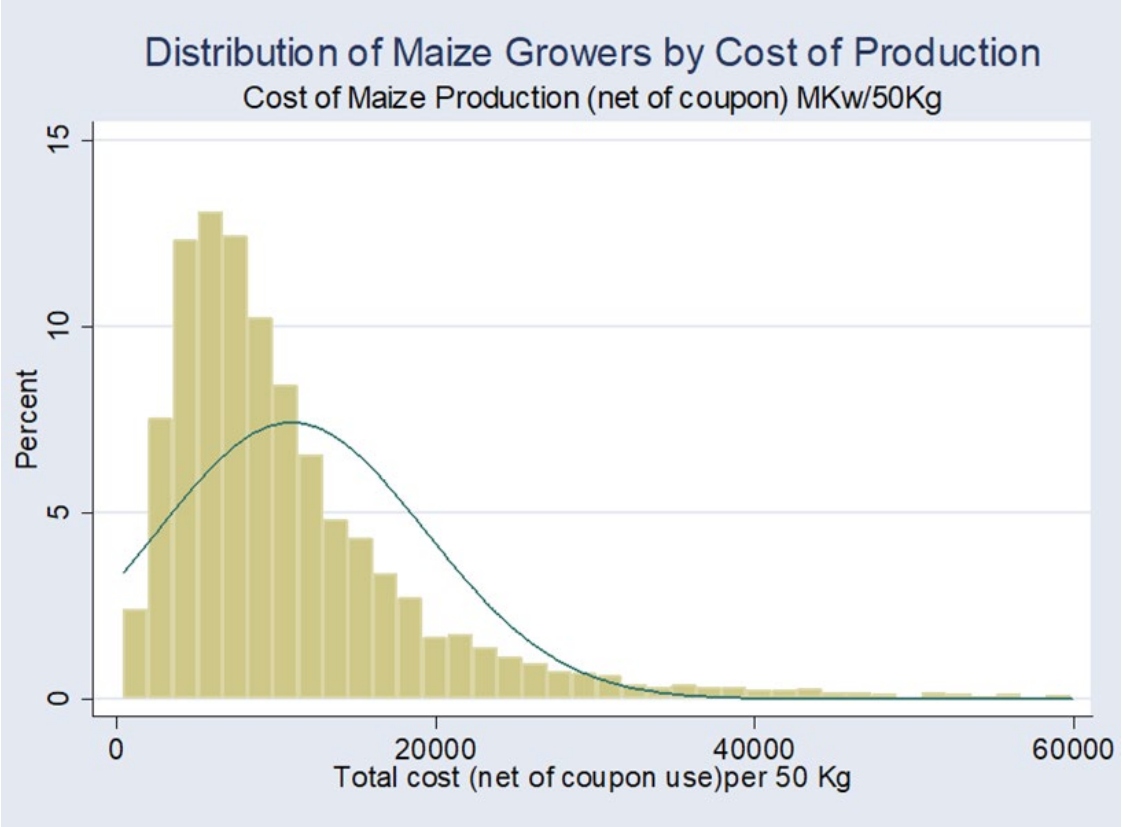
Note: Mkw refers to Malawian Kwacha (Malawi's national currency).
Source: Authors' analysis of Malawi 5th Integrated Household Survey 2019/20 (unweighted results).

4.3. Indicators and visualisations: Good practices and examples

The previous tables are computed by totalling the costs by category across all farmers and then by 'normalising' the result by dividing by an appropriate variable, again summed over all farmers. This gives average costs, which are a weighted reflecting producer size by area, production weight, or value, depending on the normalisation variable chosen.

A complementary way to compute AgCoP indicators is to carry out the computations for each individual farmer, with the final indicator computed as the average of the values across each farmer. This gives equal weight to each farmer and allows for the determination of a distribution of results and the analysis of the variability of costs across different farms. Figure 7 below, for example, shows a histogram of farmer production costs for 50 kg maize bags. The empirical distribution has been computed using a 'normality' or Gauss-curve assumption, to show that the distribution of farmer production costs per 50 kg is highly skewed towards the right: a much larger percentage of farmers produced at a cost below the farmer mean cost (identified by the peak in the distribution) than those who produced above it (if sample weights had been used, the 'Y' axes could show the actual number of farmers rather than percentages), and a small percentage of farmers produces at very high cost.

Figure 7
Distribution of growers by cost of production

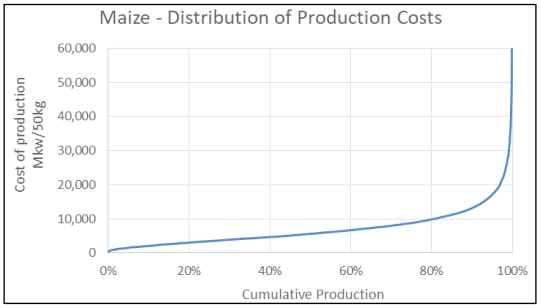


Source: Authors' analysis of Malawi 5th Integrated Household Survey 2019/20 (unweighted results)
Note 1: Mkw refers to Malawian Kwacha (Malawi's national currency).
Note 2: "Net of coupon" refers to the cost after deduction of subsidies on inputs (called coupon in Malawi).

If the farmers are placed in the rank order of their production costs per 50 kg of maize, from the lowest to the highest, and a new variable computed representing the cumulative total production up to and including that farmer (so that the cumulative production against any farmer is the sum of his / her production plus that of farmers with lower production costs), plotting production costs against the new variable gives a supply curve, as illustrated in Figure 8 below. This presents the cumulative distribution of total maize production against the cost of production (as calculated per grower). This is also an interesting way to present individual-level information on costs, as it allows to easily assess concentration of farmers with respect to production cost levels.

This figure shows, for instance, that half of all production was at a cost of Mkw 5,600 or less, with 80% at Mkw 10,000 or less. Alternatively, working from the cost level, it is possible to say that a maximum cost of Mkw 5,000 covered 44% of maize production. Again, with sample weights the 'X' axis could show the actual cumulative amount of production.

Figure 8
Example of supply curve



Note: Mkw refers to Malawian Kwacha (Malawi's national currency).
Source: Authors analysis of Malawi 5th Integrated Household Survey 2019/20 (unweighted results).

Information on the distribution of farmers according to their cost of production levels can also be presented in a more synthetic tabular format. For example, Table 4 below divides the sample of farmers into quintiles: 20% of farmers with the lowest total cost per 50 kg are in quintile 1 and the 20% with the highest production cost per 50

kg belong to quintile 5. The results shown in each of the first 5 columns are the average costs across each farmer in that quintile, while the 6th column shows the average of the costs across all farmers (giving equal weight to each grower). The final column of the table shows the production-weighted average cost of each input involved. This can be thought of as the overall average cost of producing a 50 kg bag of maize (giving more weight to the largest producers).

The first row of results in the table, above the cost breakdown, shows the share of total production by each quintile. This shows that the most efficient farmers (with the lowest costs per 50 kg) produced a greater share of maize production than their higher-cost counterparts: the most efficient farmers produced over 40% of the total output; the 20% of farmers in the highest cost quintiles produced only 7% of the total output. The average cost of production per farmer was approximately Mkw 12,000, though the cost of production for the majority of farmers was well below this level. For example, the first three columns show that over 80% of the harvest was produced by 60% of growers with an average cost range of Mkw 3,500 to 9,000.

Table 4
Production costs (MKw/50kg bag) by quintile at farmer level

Share of local maize production	Total Cost Quintile (MKw/50kg)					Mean cost per farmer	Overall production cost per 50 kg
	1	2	3	4	5		
	40.2%	22.9%	17.1%	13.0%	6.9%		
	<---------- Mean cost of production (MKw/50Kg) ---------->						
Seeds	271	369	508	678	1,424	650	330
Inorganic fertiliser	856	1,654	2,193	3,108	4,055	2,373	2,156
Organic fertiliser	76	121	164	222	322	181	108
Plant protect. Products	9	10	25	47	52	29	IS
Hired labour	96	150	170	296	364	215	276
Agric. Services	7	6	7	11	9	8	8
Land rent	46	83	95	121	137	96	71
Transport	20	48	52	89	97	61	57
Total Cash Expenditure	**1,381**	**2,442**	**3,213**	**4,572**	**6,460**	**3,613**	**3,025**
Own land use	887	1,555	2,132	3,049	6,979	2,920	1,602
Family labour	1,223	2,359	3,707	5,572	14,727	5,516	2,900
Depreciation	168	242	335	406	941	418	242
Total Costs	**3,659**	**6,599**	**9,388**	**13,599**	**29,106**	**12,467**	**7,770**
Seed coupon use	0	0	0	0	0	0	0
Fertiliser coupon use	90	218	292	418	631	330	235
Total Costs (net of coupon use)	**3,569**	**6,381**	**9,096**	**13,181**	**28,475**	**12,137**	**7,534**

Note 1: Mkw refers to Malawian Kwacha (Malawi's national currency).
Note 2: "Net of coupon" refers to the cost after deduction of subsidies on inputs (called coupon in Malawi).
Source: Authors' analysis of Malawi 5th Integrated Household Survey 2019/20 (unweighted results).

Summarizing the points covered in this Section, the following recommendations in terms of dissemination of AgCoP indicators can be made as follows:

- The results should present costs for individual inputs, where these are reliable, expressed in units meaningful to the user (e.g. per hectare, per 50 kg, per animal head, etc.) and grouped into relevant categories, for example separating cash costs from non-cash costs, self-supplied inputs or imputed costs.
- Results should show both quantities and costs. This may involve setting up and maintaining a library of conversion factors for non-standard units, including photo reference guides to identify the containers being used.
- Indicators' tables should be produced and disseminated for different geographic areas, different farm sizes, and for different groups of producers (e.g. by quintiles or deciles), with supply curves to highlight distributional effects.
- The lessons learned from the technical assistance provided by development partners to countries, as well as those from organized regional training workshops, include the need for more sensitisation of stakeholders to the usefulness of economic statistics for agriculture

and the need to produce results and information in a user-friendly format for policy makers and key partners.

As for any statistical indicators, and especially for cost indicators, which may often be computed from comparatively smaller samples, measures of precision should be provided (standard errors for sample surveys) and potential sources of biases explained.

5. Conclusion

This paper provided an overview of the approaches recommended to low- and middle-income countries on the collection, compilation and dissemination of data and indicators on Agricultural Costs of Production and revenues. More detailed information on these methodologies can be found in the publications that are listed in the references, and especially two of them: GSARS's Handbook on Agricultural costs of production statistics (2016) and the AAEA's Handbook on commodity costs and returns (2000). GSARS (2016) emphasises the approaches adapted to the context of farming systems in most developing countries, while AAEA (2000) targets farming systems and statistical offices of higher-income countries.

Considering the above, this article does not pretend to exhaustivity in the presentation of concepts and analytical procedures and the authors are aware that more comprehensive or sophisticated approaches exist and may be used to produce Agricultural Cost of Production statistics. Rather, the authors made the deliberate choice to sketch an analytical framework that may adequately account for the specificities of farming systems dominated by small-scale agriculture, that remain prevalent in most of African countries, and beyond. The approaches described and recommended in this paper also reflect more accurately the reality of agricultural statistics in these countries, which are often characterized by underfunding and lack of human and technical resources, calling for methodologies that are operational, cost-efficient and with the adequate level of sophistication, acknowledging that these may differ from the absolute gold standard. A good example of this trade-off is the assessment of opportunity costs. The authors suggest using prevailing market rates (for labour, land, capital assets, etc.) to impute non-cash costs, as a proxy of opportunity costs. Countries may also use more sophisticated approaches, based on hedonic pricing, to adequately measure the opportunity costs of specific inputs or production factors. For example, the opportunity cost of unpaid labour can be computed separately and more accurately for each household member by accounting in a hedonic regression for the key individual and common factors that may affect his/her expected income, such as the sex, age, level of education, labour market conditions in the locality, and several other parameters.

It is also important to stress that the approaches and examples presented throughout the paper are the result of methodological and technical assistance work conducted since 2013 under the combined leadership of AfDB, FAO, and others, involving in one way or another most countries in Africa and beyond (in Latin America and Asia). Most of these approaches have been tested in real conditions and can therefore be applicable to these countries in order to generate the information required by users of economic statistics for agriculture, both from the public and private sphere, starting with the farmers themselves.

Going forward, it would be useful to replicate this analysis using additional data sources from other countries of the region and beyond, to provide further insights on the applicability of the recommendations and technical suggestions - especially in relation to the modelling approach - beyond Malawi and their robustness to other contexts and conditions.

References

American Agricultural Economics Association. (2000). Handbook on Commodity Costs and Returns, Ag Econ Search, Ames, Iowa.

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

Dillon, A., Carletto, G., Gourlay, S., Wollburg, P., & Zezza, A. (2021). Agricultural Survey Design: Lessons from the LSMS-ISA and Beyond. Washington DC: World Bank.

Gaddis I., Oseni G., Palacios-Lopez A., Pieters J. (2021). Measuring Farm Labor: Survey Experimental Evidence from Ghana, The World Bank Economic Review, 35(3), 2021, 604–634.

Global Strategy to Improve Agricultural and Rural Statistics (2014), Literature review on cost of production methodologies, Technical Report Series GO-04-2014. FAO: Rome.

Global Strategy to Improve Agricultural and Rural Statistics (2016), Handbook on Agricultural Cost of Production Statistics, Handbook and Guidelines. FAO: Rome.

Global Strategy to Improve Agricultural and Rural Statistics (2016), Country Field Test and Desk-Study Report, Technical Report Series GO-13-2016, FAO: Rome.

Global Strategy. 2017. Productivity and Efficiency Measurement in Agriculture: Literature Review and Gaps Analysis. Technical Report no. 19. Global Strategy Technical Report: Rome.

Global Strategy. 2018. Guidelines on the measurement of agricultural productivity and efficiency. Global Strategy Guidelines: Rome.

Methodology for Poverty Measurement in Malawi 2016/17 (2018), National Statistics Office, Malawi & Poverty and Equity Global Practice, World Bank, Zomba, Malawi.

Oseni, G., Durazo, J., & McGee, K. (2017). The Use of Non-Standard Units for the Collection of Food Quantity: A Guidebook for Improving the Measurement of Food Consumption and Agricultural Production in Living Standards Surveys. Washington DC: World Bank.

Report on Training Workshop on Cost of Agricultural Production Statistics for French-speaking countries, 7-11 March 2016, AfDB & Global Strategy, Hammamet, Tunisia.

Report on Training Workshop on Agricultural Cost of Production Statistics for English-speaking countries, 3-7 April 2016, AfDB & Global Strategy, Cairo, Eqypt.

Report on 2023 Regional Training Workshop on Agricultural Cost of Production Statistics for African Development Fund (ADF) countries, 12-16 September 2023, AfDB & COMESA, Lilongwe, Malawi.

Sagesaka A., Palacios-Lopez A., & Amankwah A. 2021. Measuring Agricultural Labor: A Guidebook for Designing Household Surveys. World Bank, Washington DC.

Technical Note on Non-Standard Units (2021), 50x2030 Initiative to Close the Agricultural Data Gap, World Bank, Washington DC.