Unit process data collection for specialty crop production

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Abstract

The United States Department of Agriculture (USDA) collects and releases a substantial amount of commodity crop production data to inform market activities. These data are frequently transformed into unit process data, which are used in life cycle assessments of agricultural production or agriculturally derived products. The USDA has recently transformed its Agricultural Resource Management Survey (ARMS) data into high quality and transparent unit processes that represent United States production for nine commodity crops in the USDA Life Cycle Assessment (LCA) Commons. However, neither high quality and transparent unit process data, nor complete input and yield data for specialty crops exist. State enterprise crop budgets are a consistent data source for specialty crop production and have been used in past agricultural LCAs (Adom et al. 2012, Matlock et al. 2008 and Eranki and Dale 2010). One of the major objectives of this project was to determine the reliability of "state enterprise crop budgets" as tools for collecting unit process data for crop production. This paper evaluates the applicability of state cost of production (COP) estimates, which underlie state enterprise crop budgets, to LCA.

State extension agricultural economists compile enterprise crop budgets from surveys of horticultural scientists, agricultural suppliers, marketers, crop consultants, and other local and regional stakeholders. The crop budgets define a range of management practices that vary based on local conditions and estimate the costs and revenues associated with production. Crop budgets are pragmatic and based on survey results from industry experts. However, crop budget survey methods are not necessarily standardized and may not be a reliable sampling of the industry. They can have a varying level of technological, temporal, and geographic specificity and vary across states such that state comparisons or multi-state aggregations may not be reliable. Therefore, indiscriminately transforming enterprise crop budget data into unit process data may not be scientifically defensible. Life cycle inventories calculated from corn production unit processes developed from the 2005 Iowa state enterprise crop budget for corn will be analyzed and compared to unit processes developed from USDA crop production surveys.

1. Introduction

The first objective of this work is to determine if "state enterprise crop budgets" and the "cost of production (COP) estimates," upon which they are based, can be reliably transformed into "unit process" data for strawberry crop production. We refer to gate-to-gate crop production as a unit process here, with a functional unit of a unit of crop produced, which is a part of larger product systems not treated in this paper.

In 2012, USDA-National Agricultural Library (NAL) released the *Life-Cycle Assessment Commons,* an open source, life-cycle inventory database for nine (9) commodity crops. The main data source used for developing unit processes for commodity crops is the annual USDA Agricultural Resource Management Survey (ARMS) (U.S. Department of Agriculture, Economic Research Service 2013). ARMS data are derived from an annual, national, statistical survey of field-level farm practices sponsored jointly by USDA Economic Research Service (ERS) and the USDA National Agricultural Statistics Service (NASS). USDA-NAL has transformed ARMS and NASS Quick Stats data into high quality and transparent unit process data that represent United States commodity crop production and can be used in life cycle assessment of agriculturally derived products. Crop production survey data represented in ARMS covers land occupation and transformation from previous crops, seed use, irrigation, tillage, crop residue management, and the use of nutrients, manure, and pesticides. When these data are combined with NASS Quick Stats data representing field crop production for each ARMS crop-state-year combination, the basis for an LCA unit process data flow is created.

A comprehensive federal survey of production practices or cost of production does not exist for specialty crops. USDA-NAL is investigating the transformation of crop production practices data that underpin the variable cost estimates of state enterprise crop budgets into unit process data that can be used for life cycle assessment of specialty crops. However, when analysts transform existing data for unintended uses, they must fully understand how the intended use and collection methods relate to the new questions they are asking. ARMS data were appropriate for transformation into commodity crop unit process data that represent U.S. agriculture because they were developed from a statistical sampling that represented historical activities. Their state level resolution and historical perspective make these data suited for policy analysis more so than producer planning purposes. Conversely, state cost of production estimates are not necessarily statistical samples and are

developed for planning purposes. Therefore, they may not be representative of typical production practices and may not be adequate for policy analysis.

2. Methods

The basis for this work is a qualitative literature review and meta-analysis of the methods behind state and federal COP data. Our hypothesis is that the state COP data that underpin crop enterprise budgets are representative of state level management practices. This hypothesis is being tested with a two phased approach. The first phase, documented here, is a qualitative review of COP estimate methods and their applicability to LCA. The second phase is a quantitative meta-analysis that will compare life cycle inventory results from unit process for corn production developed from USDA ARMS data that reside in the USDA LCA Commons and corn production unit processes developed from state COP data collected by varying methods. Phase two results will be documented in a separate paper and presented at LCA Food 2014.

3. Results

Inconsistencies between the methods used by land grant universities developing state level COP estimates and USDA's Farm Cost and Returns Survey (FCRS) methods surfaced during congressional deliberations on the 1990 Farm Bill. Policy makers and researchers found that the variety of methods used in collecting, calculating, and analyzing state and national cost of production estimates yielded inconsistent analytical results. Essentially, using COP data gathered on a local or regional level with the intended use of improving farm management were not necessarily transferrable for federal policy making. Libbin and Torrel compared data collected in the 1986 crop and livestock budgets for New Mexico with data collected through the FCRS in that year. They found tremendous discrepancies among the state and federal data mainly due to methodological differences in data collection (Libbin and Torell 1990). An exploration of the discrepancies in state and federal cost of production estimates were formalized in a volume of Costs and Returns for Agricultural Commodities (Ahearn and Vasavada 1992), with the over- arching recommendation that states and the USDA must collaborate to coordinate state and federal cost of production estimation methods. As a result, the Commodity Costs and Returns Estimation Handbook was developed and is hosted on the web by the USDA Natural Resource Conservation Service (NRCS). The "handbook's purpose is to gather in one place information on estimating costs of and returns to agricultural enterprises (American Agricultural Economics Association 2000). In addition to publishing the Handbook, these activities culminated in the evolution of FCRS into the Agricultural Resource Management Survey in 1996. Presumably, the Handbook produced by this process helped align the methods used in state and federal cost of production estimates for commodity crops to support more consistent analyses.

3.1. Transforming COP Data into Unit Process Data

Transforming state COP data into unit process data requires an understanding of both the intended uses and data collection methods of COP data. In the Costs and Returns for Agricultural Commodities (Ahearn and Vasavada 1992), House (1992) and Guedry caution that the intended use of the COP data should determine the data collection methods. Alternatively stated, data collection methods must support their ultimate use. Guedry asserts that the purpose for which COP estimates are used influences the manner in which they are collected and that [if they are going to be used for research] analysts should focus on the differences that exist in the data and the procedures used in developing the estimates, rather than the formats in which they are presented (Guedry 1992). This statement is particularly pertinent for analysts using data for purposes other than their intended purpose. In this case, cost data are not being collected and used for economic analysis, but rather existing cost data are being used for environmental analysis. Klonsky asserts that in developing COP estimates each institution's methods are constructed following an internally standardized set of methods, but the methods used to estimate cost vary from state to state (Klonsky 1992). These variable methods may include both the intended uses of the COP estimates and the sampling methods.

3.2. Intended Use of COP Estimate

COP estimates are generally used for three purposes 1) assisting farmers in planning and improving their management performance 2) policy analysis (Morehart, Johnson, and Shapouri 1992) and 3) research activities (Guedry 1992). Therefore, cost of production information is of interest to farmers, farm management specialists, policy makers and researchers (Ikerd 1992). Subsequently, the first question that should be asked when using these data for analytical purposes is, "what does the economic [or life cycle] analyst need from a cost and returns data set? (House 1992)." It is proposed here that the material and energy input and output data be used to model field scale environmental emissions. Because results could inform both growers in improving production practices and/or commercial and government policy decisions, it must be determined if state strawberry crop production estimates provide an adequate representation of state-wide production. Indeed, many state enterprise crop budgets include a disclaimer that production practices and their associated costs may not be representative of production practices and costs throughout the state. Furthermore, "one fundamental difference among enterprise budgets is that some are intended to reflect historical events and are summary for the current year. Others are intended to be projections of costs for the coming year (Klonsky 1992)." The strawberry state enterprise crop budgets used in this study indicate that they represent "typical" state level production.

Extension economists may want to develop Cost and Return (CAR) estimates that are representative of progressive, well-managed farms (rather than all farms) engaged in the selected enterprise because those estimates may be more useful in guiding potential producers. On the other hand, the United States Department of Agriculture (USDA) and others producing historical estimates generally want to include a broader geographic area and to target all farms engaged in the enterprise regardless of whether they are progressive or not (American Agricultural Economics Association 2000) Therefore, state enterprise crop budgets may represent "target yields" or "safety first" estimates that may not necessarily be representative of typical production (Schoney 1992). However, enterprise cost budgets are usually part of on-going and even long-term programs in which production practice and cost estimation methods have been refined over time. The data quality conferred by the longevity and expertise of the stakeholders involved in developing state cost of production estimates is certainly implicit, if difficult to measure.

3.3. Data Collection Methods

If the intended uses of the COP data collection yield data that are representative of crop production practices, the methods by which COP data are collected must also yield representative estimates. The most important factor in assuring data quality is statistical inference. Statistical inference determines whether, and to what extent, results from the analysis and estimation can be generalized to a broader set of farming operations. Statistical inference is largely determined by two activities: precisely defining the group (or target population) the analyst wants to investigate, project for, or draw conclusions about; and selecting representative data from that population for the analysis. There are two sampling methods that allow analysts to select a representative sample of data from the target population in such a way that valid inferences can be maintained: a statistical sample and a judgment sample (American Agricultural Economics Association 2000).

A statistical/probability sample is considered superior to a judgment/non-probability sample. A statistical/probability sample is one in which each farm in a targeted population has a positive and knowable chance of being included and produce data that are representative of the entire target population. Judgment samples, on the other hand, are selected through some method other than statistical sampling, usually the subjective decision of one or more individuals. Consequently, at least some members of the target population did not have a chance to be selected. Judgment surveys are not necessarily inaccurate, but it is also not possible to determine if they are accurate either. The accuracy of the sample depends on the expertise of the individual selecting the sample (Williams 1978). State COP estimates are usually derived from judgment samples of the local and regional industry. In rare cases, state COP estimates are derived from statistical samples for commodity crops. However, statistical sampling is cost prohibitive and it is not realistic to accomplish for each specialty crop or even each commodity crop in each state in every year.

In fact, statistical sampling may not be appropriate for specialty crop COP data collection. Judgment samples may produce more reliable data when the sample size is very small. Also, depending on the specialty crop and state, judgment samples may be more effective in terms of cost and reliability. Another disadvantage of

probability surveys is that they are not collected longitudinally and lack richness over time. State COP estimates, on the other hand, "are designed to provide usable estimates within the resource constraints of those preparing the estimates. Information that is developed annually is, in general, part of an ongoing educational program that has been developed over a period of years. Such programs have an advantage of being validated annually by users (Guedry 1992)." The veracity of the data gathered through long-term judgment sampling is likely to continue to be improved over time and may be more representative of reality than statistical sampling.

4. Discussion

The results of this review indicate that transforming state enterprise crop budgets into reliable unit processes for life cycle assessment is feasible. The "static snapshot" of COP estimates for an agricultural enterprise is aligned with the nature of a unit process. However, several subtle issues with respect to the use of crop budget derived unit processes in life cycle assessment became apparent. Primarily, cost estimates cannot be categorically transformed into flow data and data collection methods vary among states and unit processes developed from state COP data must be used with caution in LCA. COP data collection methods must be understood, reconciled across states, and fully documented if the unit processes are used as part of an aggregation or comparative LCA. Aggregations or comparisons across states cannot be reliably made based on state COP estimates. Second, the data used to build state enterprise crop budgets do not necessarily produce "representative" production practice data. Before using an enterprise crop budget, the life cycle analyst must endeavor to understand how the data were collected and for what purpose. Unit processes for a single state is reliable if the crop budget states that production practices and costs are representative of state-wide production. A statistical sample is not essential for collecting reliable data, but the survey must be deemed to be representative of current activities.

Most state COP estimates for commodity crops are based on judgment samples because the cost of ongoing statistical sampling is cost prohibitive. State specialty crop markets cannot bear the costs of ongoing statistical sampling either. However, statistical sampling may not be appropriate for state specialty crop markets due to small sample sizes of producers in each market. The ongoing, annual sampling of the industry and continuous improvement of methods and estimates provides confidence in the quality of COP data collection methods. State economists sample the local and regional industry over a period of years and continuously endeavor to improve their methods and estimates. The institutional knowledge and continuous improvement developed over a period of years in these programs provides confidence that state COP estimates and their underlying production practices do, indeed, represent state production. These data may be more reliable than a statistical sample of the same market.

5. Conclusion

While data collection methods for state enterprise crop budgets are reliable and internally consistent within a state from year to year, survey methods vary among states. Therefore, budgets must be individually evaluated to determine if they are reliable for comparative LCA. Unit processes can be reliably developed for individual states, but differences in data collection methods among states must be reconciled before the unit processes are used in LCA. If state enterprise crop budgets as a whole are to be reliable data sources for LCA, data collection methods must be standardized beyond format. State enterprise crop budgets are designed for field-level micro-economic planning and may not provide the resolution of input/output data necessary for a detailed field-level LCA. For example, a budget may estimate an aggregated cost for pesticides required for a crop in that year, but may not define which specific pesticides or the quantity of those pesticides used. Crop budgets may be more appropriate for developing background unit process data for more complex agriculturally derived products rather than higher resolution data required to inform field level activities. In the absence of standard methods across states, the analyst must understand and reconcile variability among states before making comparisons and the intended use of the budget. The variability among state budgets and their intended application must be fully transparent in the LCA documentation.

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