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From Tragedy to Renaissance

Improving Agricultural Data for Better Policies

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Abstract

Agricultural development is an essential engine of growth and poverty reduction, yet agricultural data suffer from poor quality and narrow sectoral focus. There are several reasons for this: (i) difficult-to-measure smallholder agriculture is prevalent in poor countries, (ii) agricultural data are collected with little coordination across ministries of agriculture and national statistics offices, and (iii) poor analysis undermines the demand for high-quality data. This paper argues that initiatives like the Global Strategy to Improve Agricultural and Rural Statistics bode well for the future. Moving from Devarajan's statistical "tragedy" to Kiregyera's statistical "renaissance" will take a continued long-term effort by individual countries and development partners.

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From Tragedy to Renaissance:
Improving Agricultural Data for Better Policies

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I. Introduction

Agricultural development is an essential engine of poverty reduction in Sub-Saharan Africa, where an estimated 75 percent of the extreme poor reside in rural areas (Livingston et al. 2011) and are largely engaged in agriculture-related activities. While the exact relationship between poverty reduction and agricultural growth in any country depends on the agricultural and social structure of a given location (DFID, 2004; Prowse and Chimhowu, 2007), development in the agricultural sector tends to result in greater benefits accruing to the poorest segments of the population, with a 1 percent rise in agricultural GDP resulting in an estimated 6 percent increase in income growth for the poorest 10 percent of the population (Chen and Ravallion, 2007; Ligon and Sadoulet, 2008).

The connection between agricultural growth and poverty reduction has been tied to various pathways, such as the creation of wage employment in rural areas. In particular, growth in smallholder agricultural productivity continues to be heralded as a key driver of poverty reduction: for every 10 percent increase in farm yields, Irz et al. (2001) estimate that there has been a 7 percent reduction in poverty in Africa. Given that the pool of smallholders on the continent is vast, with approximately 33 million farms of less than two hectares in size,[1] policies that increase the productivity of small-scale farmers can serve as important drivers of poverty reduction and improved food security in Sub-Saharan Africa.

Despite the key role of smallholder agriculture in the sector and the economy as a whole, serious weaknesses persist in the measurement of agricultural outcomes and in our understanding of the factors hampering agricultural growth among smallholders. While governments and donors alike target agriculture for large-scale investments with ambitious goals of raising agricultural productivity multi-fold, little is done to ensure that accurate statistics are produced to monitor agricultural development. For instance, of the 44 countries in Sub-Saharan Africa rated by the Food and Agriculture Organization, only two are considered to have high standards in data collection, while standards in 21 countries remain low (FAO, 2008). Other studies have likewise noted that data quality issues limit analysis (Ngendaumana, 2001; Tiffen, 2003). Past investments and technical assistance efforts in the area of agricultural statistics have failed to produce sustainable systems, while existing statistics continue to suffer from poor quality, lack of relevance, and little use in national policy dialogues (Binswanger, 2008). Further compounding the problem is the fact that the poorest countries – for which agriculture is a critical source of livelihood – often have the poorest data, being least able to direct their limited resources into improving the quality of their statistics (African Development Bank, 2004).

In spite of the clear need for empirical evidence, these countries lack the financial resources to generate survey or administrative data of sufficient quality and scope to inform policy, let alone to fund these policies. In the 2003 Maputo Declaration on Agriculture and Food Security in Africa, in recognition of the importance of the sector for the 'economic prosperity and welfare of its people', African countries committed to allocating at least 10 percent of national budgetary resources for the implementation of sound policies for agricultural and rural development (African Union, 2003). However, a 2011 report on financial resource flows to agriculture by the FAO found that although government spending on agriculture has increased for developing countries as a whole, it has decreased as a share of total spending, perhaps indicating issues with political will regarding agriculture in addition to budget constraints. In particular, one of the key messages of the report was that "trends in indicators of government spending on, ODA to, and FDI in agriculture are discouraging for Sub-Saharan Africa" (FAO, 2011; pg. 37).

Even with sufficient financial resources, countries often lack human resources to collect data in a cost-effective and sustainable manner. External support from donors can provide a short-term patch, but typically has not been successful in leaving in place sufficient capacity to continue the data collection work when the support ends. The low level and inconsistency of budgetary contributions to statistics from own governments, as well as erratic and short-term donor support, directly results in inconsistencies in data collection activities in many countries. This has significant implications for data quality.

As one example, if the implementation of a survey depends on irregular financing by donors, it becomes extremely difficult to plan in advance for multiple years of survey efforts with any degree of certainty, which in turn has negative repercussions for the collection of time series and panel data. However, as much of the existing agricultural data are cross-sectional, the data are unable to track the changes in indicators over time, or to follow important phenomena such as the transition out of agriculture into potentially higher-return activities. In their review of agricultural development, rural non-farm activities, and rural poverty, Foster and Rosenzweig (2008; pg. 3055) note that “very few studies permit direct comparison over time using comparable measures.”

The challenge of improving agricultural statistics worldwide is daunting. Recent efforts such as the Global Strategy to Improve Agricultural and Rural Statistics (henceforth, referred to as the Global Strategy) and the ensuing regional Action Plans are testament to the renewed commitment of the global community of researchers and practitioners to rejuvenate the sector, following decades of under-investment (World Bank, United Nations and FAO, 2010). The first pillar of the global strategy focuses on the identification and establishment of core data with a focus on agricultural productivity and the most important crops to global agriculture production.

Due to the enormity of the task at hand, this paper sets out to inform the debate in a targeted and selective fashion by addressing a number of specific issues which are the focus of a recent initiative, namely the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA).

Specifically, two claims are made. First, in the advent of new technologies becoming increasingly available at relatively low costs, more rigorous research is needed to create and promote improved, cost-effective standards in agricultural statistics. Improvements in methods for collecting smallholder agricultural statistics have been particularly sluggish over the past three decades and present the typical market failure problem, with clear disincentives for private investments. For instance, the latest guidelines by the FAO on yield measurement date back to the early 1980s, when modern technologies were not available (FAO, 1982). The lack of up-to-date research on survey methodologies has led to serious gaps in the existing knowledge base, limiting the identification and promotion of effective policies. Second, statistical systems for agriculture lack integration, limiting the utility of the data for examining linkages between agriculture and key issues such as poverty or nutrition, as well as linkages between socioeconomic variables and environmental conditions. In order to better inform agricultural policies, approaches based on the enhanced integration of agricultural data and other types of data sources are needed.

This article is not meant to be a comprehensive review of the issues plaguing agricultural statistics but a purposive discussion of selected shortcomings of current systems. Its contribution is meant to focus on a number of well-defined issues which we believe to be both tractable and to offer a high return in terms of data quality and policy relevance. In the ensuing discussion, emphasis is placed on the African continent due to the geographic focus of the LSMS-ISA initiative as well as the greater potential of smallholder agriculture for poverty reduction and growth, highlighting the importance of overcoming what Devarajan deems a "statistical tragedy" towards creating innovative, well-informed agricultural policies (Devarajan, 2013).

II. Agricultural statistics in Africa: An irreversible tragedy?

Problems with agricultural statistics are not confined to the African continent, as highlighted by Indian Prime Minister Singh in a speech addressing the state of statistics in India (Singh, 2006). Neither are they new, as reported by Parker Willis in his 1903 exposition of the large discrepancies in US agricultural data (Willis, 1903). However, in light of the key role played by smallholder agriculture in the economies of African countries, gaining a better understanding of the sector based on sound statistics ranks high in the current continental policy agenda.

A few examples below illustrate existing problems with core agricultural statistics and also highlight some encouraging trends. Figure 1 presents estimates of the annual average maize yields in Tanzania, as reported by FAOStat.[2] The massive 2-year decline, dropping by an estimated 2,381 kg / hectare between 2001 and 2003 after a threefold increase since the late 1990s, seems in itself *prima facie* evidence of a data quality issue. These huge swings are rendered even more concerning by a lack of documentation explaining how reported yield could have first climbed to unusually high levels in the early 2000s and then declined by more than 75 percent in this short period. While sharp increases observed in input use and cultivated land in the early 2000s may partially explain some of the trends, the magnitude of the changes and the limited information available regarding the data collection processes casts doubt upon the accuracy of the reported estimates. Nonetheless, as seen in Figure 1, the recent trends are more credible, suggesting a possible improvement in the quality of the estimates.

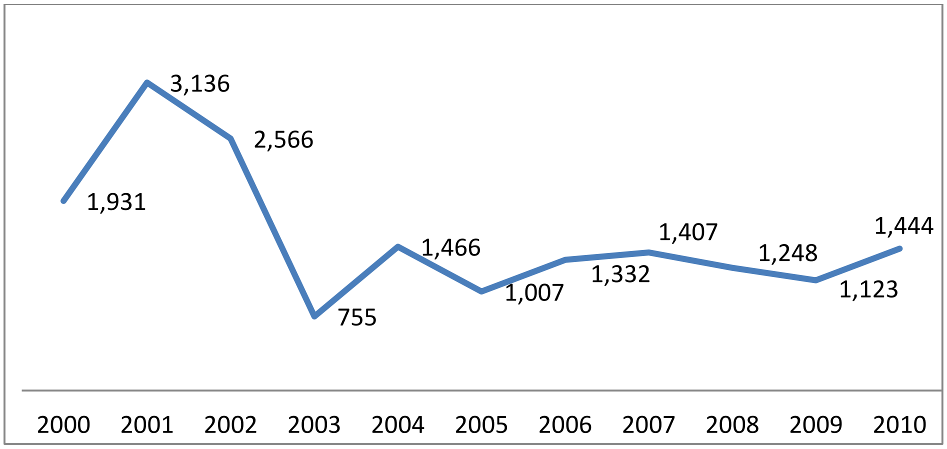

Figure 1: Maize Yields in Tanzania, *kg* of maize per hectare
Source: FAOStat

Another issue is the occurrence of conflicting estimates for the same indicator in the same country for the same year. In Figure 2, we illustrate this issue by reporting maize yield estimates for Malawi for 2006-2007 from the three available sources, namely the routine data system from the Ministry of Agriculture, the National Census of Agriculture and Livestock (NACAL) conducted by the National Statistical Office, and from the FAO. The differences are significant and have been at the center of much debate both within the country and among development partners. While some variation in the estimates is to be expected as a result of differences in both survey methodology and sampling, reaching an understanding of what drives these differences has been difficult.

There are also significant differences in the estimates of the total number of farm households between the Malawi Ministry of Agriculture (3.4 million farm households) and the Malawi National Statistical Office (2.47 million rural households), which in turn affects not only total production estimates but also the planning effectiveness for the subsidized input program (Dorward et al, 2008). On a similar note, Elepu (2006) explores the difficulties inherent in simple quantification of declining agricultural production in Uganda. Furthermore, due to the general lack of documentation describing the data collection and estimate production processes, no informed conclusions can be drawn as to the accuracy of a given estimate.

In some countries, ambiguity in the institutional mandate for the collection of agricultural statistics complicates even further the establishment of credible, core data for agricultural statistics. For example, until recently, crop production estimates in Ethiopia were produced by both the Ministry of Agriculture and Rural Development (MoARD) and the Central Statistical Agency (CSA). The discrepancy in the estimates has always been striking, with MoARD estimates considerably higher than the already high CSA estimates (Dercon & Hill, 2009). The fact that the two estimates differ significantly should come as little surprise in light of the different methodologies used to estimate both area under cultivation and total production, but this does little to help assess which estimate is closer to the truth.[3]

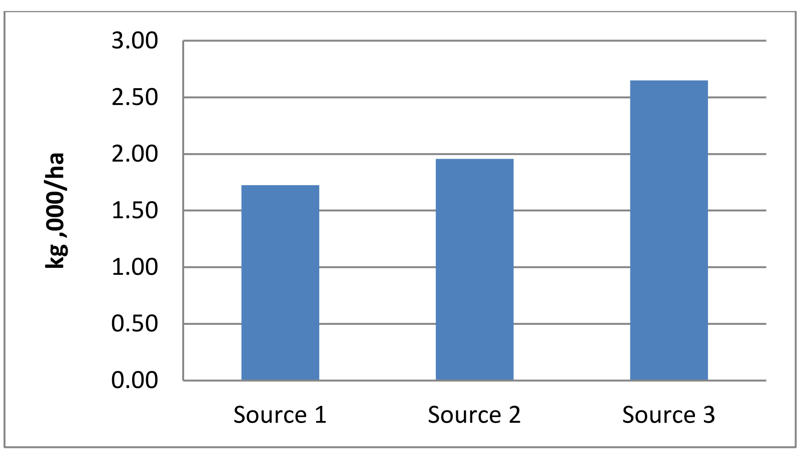

Figure 2: 2006-2007 Maize Yields from Malawi
Sources: Source 1: NACAL; Source 2: Ministry of Agriculture; Source 3: FAO

III. Measuring and understanding the role of agriculture

(i) Data sources on agriculture

Agricultural data often come from different institutional sources, typically resulting in conflicting estimates. The institutional setting for the collection of agricultural data engenders poor coordination and inefficient outcomes. Traditionally, agricultural statistics have been collected outside of the National Statistical System (NSS), with little oversight by the National Statistical Office responsible for the enforcement of statistical standards. Oladejo et al. (2010) argue that the lack of mainstreaming agricultural statistics into the NSS is one of the underlying causes of the poor state of the numbers. Reinforcing these problems is the compartmentalized set-up and *modus operandi* of development partners in focusing on agriculture while ignoring the rural space and, more generally, the ecosystem in which it takes place.

Routine data systems based on resident or local extension officers employed by the Ministry of Agriculture exist in virtually all countries. Extension officers collect different types of data on a frequent basis at a geographically granular level, including information on land usage, crop forecasting, and production. One major drawback of current routine data systems is the high degree of arbitrariness and subjectivity in data collection protocols. A second source of agricultural data is the agricultural census, also usually implemented by the Ministry of Agriculture at times in collaboration with the NSO, which countries are recommended to implement every ten years according to FAO guidelines. Agricultural censuses are an indispensable source of information to characterize the sector at finer geographic resolutions and provide the basis for sampling farming units for more in-depth surveys. However, because of the high costs of full enumeration and the limited amount of information collected, agricultural censuses are increasingly less common.[4]

Sample surveys are the third source of data on agriculture. Farm surveys remain the backbone of agricultural statistics in Africa, with great variation in terms of content, frequency and quality. While in principle indispensable for obtaining a solid depiction of the agricultural sector based on sound statistical foundations, this type of survey suffers from a key drawback: by focusing almost exclusively on the measurement of agriculture, they generally lack sufficient information to understand it as part of a larger context and to thus serve as a useful input for guiding policy making. Even among the most remote and poorest of rural households, agriculture does not exist in a vacuum, and diversification in terms of income sources at both the household and individual level is the norm, not the exception (Davis et al., 2010). This income source diversification in rural areas may be even greater than the current data suggest; recent research highlights the limitations of existing rural socioeconomic studies, pointing to large numbers of wage workers in rural labor markets in Africa that have not been accurately captured by current survey methodologies (Cramer et al., 2014). Furthermore, important policy questions such as understanding the role of agriculture in poverty reduction or the distributional impact of certain sectoral interventions require the collection of agronomic, livelihood and welfare data from the same household, which is beyond the realm of traditional farm surveys.

In many countries, farm surveys are often complemented by other types of household surveys that capture agricultural issues to some extent, conducted by national statistics offices or even private organizations or firms. These surveys generally use population-based listing as sampling frames and use the household, and not the farming unit, as the unit of selection and analysis. There are obvious advantages and disadvantages to the two approaches; however, based on the need to better integrate agronomic and environmental variables at the farm and locality levels with socioeconomic characteristics at the household and individual levels, the utility of such integration is increasingly accepted. This integration, which is one of the pillars of the Global Strategy, can be achieved through improved linkages across different data sources, through incorporating different types of information into the same household questionnaire, or both.

While linkages across different data sources by means of thematic overlap, sampling or geo-referencing should be promoted whenever possible, for certain types of analyses, there is no alternative but to collect all information from the same household at the same time through integrated surveys. Relying on multi-purpose surveys to collect data on agriculture also presents its challenges. When integrating different sectoral information into a single questionnaire, the breadth of the data collected may necessitate compromises in depth in order to prevent the time burden placed on the respondent from becoming too onerous. Additionally, the timing and frequency of the visits must be adjusted to the agricultural season due to the added requirements of collecting information on highly seasonal and volatile processes.

(ii) Limitations of existing agricultural data

Compounding the problem of poor agricultural statistics is the limited policy relevance of the available data. Policy interventions and rural poverty reduction strategies often assume the existence of a strong relationship between increasing smallholder agricultural productivity and poverty reduction; however, even when that is the case, there is no single policy lever that directly increases productivity. Rather, a farmer's productivity is the result of a complex interaction of markets for farm inputs and outputs, credit markets, agronomic and environmental factors, human and social capital, and government policy. In many countries agricultural data are collected with insufficient information on important domains (such as health, labor, education, wealth) to better understand how to inform policy with the goal of increasing agricultural productivity and ultimately improving the wellbeing of the rural poor.

The difficulty of collecting reliable and representative agricultural data is only part of the problem. A better measure of crop production or yields in isolation cannot and should not change social policies. The ultimate goal of national policies is to improve the wellbeing of the populace, and the link between agriculture and improved wellbeing can be made through a wide variety of channels. Agriculture comprises only one component of complex household income-generating strategies that involve multiple individuals and activities in different sectors (Davis et al., 2010; Foster and Rosenzweig, 2008; World Bank, 2008). Smallholder diversification into non-farm activities has evolved to be the norm rather than the exception (Reardon, 1997; Bryceson, 2002; Davis et al., 2010). This diversification takes place both at the household and the individual level (Jolliffe, 2004); by taking advantage of different income sources, the rural poor can achieve higher incomes and lower risk exposure. During the idle months of the agricultural season, for example, farmers that are able to operate a small family business or take on daily wage labor will be better able to provide for themselves as well as insulate themselves and their families from shocks related to their agricultural output.

Given the ubiquity of such diversified income-generating strategies among the rural poor, it is of particular importance to capture a comprehensive set of information on these households in order to better understand the linkages between farm and non-farm activities, as well as between agriculture and different aspects of wellbeing such as nutrition and food security. Understanding these linkages requires an integrated approach to the collection of household survey data, which allows for linking welfare and agricultural information in order to draw conclusions about the distributional effects of agriculture nationwide. The fact that rural economies are diverse and that this diversification is found even within households was recognized by the Task Team on Food, Agriculture and Rural Statistics (Paris21, 2002), whose key recommendations included rethinking agricultural surveys by broadening their scope to include both agricultural and non-agricultural activities, as well as by improving the coordination of the various agencies responsible for the production of agricultural statistics.

If countries were able to regularly collect reliable, nationally-representative agricultural data in a multi-topic, multi-sectoral LSMS-type instrument that accounted for differences across individuals within the households, this would be a tremendous step forward. However, this alone is insufficient to ensure that the data will be used to help shape better policy: creation of the right input does not ensure that it will be properly used if it is not shared or understood. Regrettably, as mentioned above, agricultural data are often collected in institutional isolation, with little coordination across sectors and little analytical value-added beyond the sector. Thus, in many countries, the data collected by the ministries of agriculture are not linked or utilized in conjunction with data available from the national statistical offices or other line ministries such as labor, education and health. Linking this information would allow, for example, for better targeting of government subsidy programs such as the Fertilizer Input Subsidy Program in Malawi. Coordination requires communication, and a key form of communication is the ability to share and exchange data. The most effective way for different data files to speak to each other is to have common identifying traits in each file allowing data from different agencies and institutions to be easily merged. Without these standardized identifying variables, the data files will remain isolated; with them, the potential value of the data to inform policy is greatly enhanced. Most countries with well-functioning data infrastructure solve this problem via standard identification for geographic regions, or by embedding internationally accepted measures of location such as latitude and longitude degrees. However, in most Sub-Saharan African countries, this self-imposed discipline of using standard codes across Ministries is not commonplace and the result is a series of agency-specific data silos rather than effective national data architecture. The systematic geo-referencing of household and plot level information can partly ameliorate the problems created by missing or inconsistent geographic coding and changing boundaries. In light of the low and ever decreasing costs of GPS units, the routine collection of geo-referenced information is now possible on a large scale.[5] Linking socioeconomic and farm-level variables collected in household surveys with environmental information from remote sensing and other spatial data sources is crucial to gaining a more comprehensive understanding of farm outputs.

Another cause of poor data that warrants mention is the lack of analytical capacity in developing countries, which has created a vicious cycle of poor analysis undermining the demand for high-quality data. Poor dissemination of the available data and results (due to competing donor demands or simply poor management) has further aggravated the problem. For example, the national and regional reports from the 2003 Agricultural Census Sample Survey (ACSS) in Tanzania were only produced in 2006-2007.[6] Although these problems are common to developing countries around the globe, the problem appears to be more acute in Sub-Saharan African countries. The 2002 Paris21 Taskforce stressed the importance of strengthening the statistical and analytical capacities of these data producers.

Additionally, the role of livestock is important for many agricultural households and is also notoriously difficult to measure. For nomadic, semi-nomadic and transhumant populations, livestock serves as the primary source of welfare; even for those who focus primarily on farming, livestock ownership is often a key to increasing their standard of living. Livestock ownership can signify higher animal protein consumption, a protection or buffer against shocks, as well as a regular complementary source of income for large swathes of the population in certain African countries. A recent analysis of the 2009 Tanzania National Panel Survey found that approximately three out of five rural households reported some income from livestock activities; on average, households earned 22 percent of total household income from the rearing of livestock[7] (Covarrubias et al., 2012).

Finally, the role of politics in data cannot be ignored. These numbers, poor as they may be, are more than just numbers – they have real-life consequences in terms of costs and benefits to various political players, and as a result, it is unlikely to be the case that these statistics are finalized without at least some degree of negotiation. Jerven (2013) presents a set of case studies from India, Nigeria and Malawi on agricultural input subsidies, and finds that information that does not suit the aims of political leaders is either tampered with, or that choices are made between conflicting information on political grounds. Sandefur & Glassman (2014) find that national governments not only misreport to foreign donors, but are themselves misled by their frontline service providers. That said, it must be noted that this problem is not confined to developing countries alone, and certainly not only to Africa.

To address some of these weaknesses, the Living Standards Measurement Study (LSMS) team in the Development Research Group of the World Bank, with financial support from several donors, has embarked on an ambitious program of data production and research, in collaboration with several development partners. The primary objectives of the LSMS-ISA project are to improve our understanding of the inter-relationship between agriculture and poverty reduction, to improve the capacity of national statistics offices to collect and use these data to inform policy, and to foster innovation in the measurement of agricultural data. As such, and by working on a limited number of countries[1] and a well-defined set of statistics, the emphasis of the LSMS-ISA is

[1] Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania, and Uganda.

to support larger initiatives like the Global Strategy in making agricultural statistics more relevant to a larger audience of researchers and policy makers and raising the profile of the sector within the broader development debate. Table 1 below summarizes various attributes of LSMS-ISA surveys that establish the potential benefits that they offer for researchers in terms of moving the agenda forward on the analysis of agricultural statistics.

Table 1: Attributes of LSMS-ISA surveys

	Ethiopia	Malawi	Niger	Nigeria	Tanzania	Uganda
Panel data	✓	✓	✓	✓	✓	✓
Multi-topic information	✓	✓	✓	✓	✓	✓
Nationally representative		✓	✓	✓	✓	✓
Land area measured using GPS	✓	✓	✓	✓	✓	✓
Non-standard conversion factors		✓	✓	✓		✓
Built-in methodological experimentation		✓	✓	✓		✓

IV. Measuring agricultural productivity: In search of the "holy method"

One statistic of particular policy relevance in the poverty debate is the measurement of agricultural productivity, particularly for small farmers. Improvement in the measurement of land productivity has been identified as the highest priority in new research by the Global Strategy, a recent multi-agency initiative endorsed by the United Nations Statistical Commission in February 2010. One of the main goals of the Global Strategy is to develop new protocols and best practices for the estimation of a core set of agricultural indicators, by the promotion of rigorous research and the compilation and dissemination of key findings.

Productivity can be measured in many ways, whether based on the return to a single factor of production or multiple ones. In this section, we focus on land productivity, or yield, defined as the amount or value of crop harvested (the numerator) over cultivated land (the denominator). To this end, we describe the different methods commonly used to estimate crop production and land area, and summarize findings of recent LSMS research comparing the different methods.

The ease of collecting accurate crop production estimates varies tremendously depending upon the crop in question. For instance, while it is relatively simple for farmers to recall harvested quantities or revenues for high-value, marketed crops like rice, collecting production data for extended-harvest crops like cassava or bananas is a much more arduous task due to the nature of the production process and the length of the harvest period. Root crops such as cassava store better in the ground and the total harvest period spans several months, often through the accumulation of numerous harvest events in small quantities. The same is true for bananas, which are harvested continuously throughout the year, as well as other so-called "fast commodities" such as onions, tomatoes, peppers, and other fruits and vegetables that are produced for the many growing urban markets across Africa. Unlike bananas, however, root crops like cassava are often planted to ward off food insecurity in the case of crop failure. In many cases, therefore, they are only fully harvested when households are faced with hunger, creating further complications with regards to capturing the actual production (which may comprise only a partial harvest of the crop) relative to the potential production (that is, if the plot is harvested in its entirety).

Even for crops such as maize that are generally fully harvested in a single season, problems with quantification may still exist. First, significant portions of the total production may be harvested early while still green, particularly in contexts of high food insecurity, and thus may not be captured in the total production estimate given by the farmer. Second, many surveys do not collect information on the state of the crop, which may vary even within a single crop for the same household. For instance, maize quantities can refer to maize on the cob, in grain, or flour, and unless information on the physical state of each share of total production and on the correct conversion factors between the different states is collected, large measurement errors may result.

Complicating things further in the case of these and similar crops is the fact that they are almost invariably measured in non-standard units, for example pieces or heaps for cassava, or bunches for bananas. Even assuming that farmers are able to recall the exact number of heaps of cassava or bunches of bananas harvested over a particular reference period, given the enormous variation in weights of different non-standard units, these cannot then be accurately converted into standard units such as kilograms. Figures 3 and 4 below illustrate the problem, while Table 2 demonstrates the significant variation in weight for crops reported in terms of a '50 kg sack'.

Figure 3: Bunches of bananas and pieces of cassava

Figure 4: "25 kg" Sack of Cassava

Table 2: Weight (kg) of crops in 50 kg sack

Crop	Kg
Maize	50.0
Groundnut	44.2
Ground bean	43.2
Rice	56.2
Finger millet	50.5
Sorghum	49.6
Pearl millet	50.5
Bean	77.6
Soyabean	53.1
Pigeonpea	57.1

Source: Malawi, 2004/2005 Integrated Household Survey

Thus, with regards to improving quantification, the construction of accurate conversion factors of non-standard units is a crucial first step. As simple as it may sound, this is seldom done in a consistent and systematic manner – and when conversion factors are available, they are not easy to find, nor is the methodology on the production of the conversion factors properly documented. The construction of comprehensive libraries for all possible non-standard units in each specific region of a country is the crucial missing element and should be carried out to the extent possible for all countries in Sub-Saharan Africa. In the interim, visual aids in the form of laminated cards with pictures have been used with success in household surveys (see, for instance, the 2010-11 round (wave 3) of the Malawi Integrated Household Survey). The use of new technologies like Computer Assisted Personal Interviewing (CAPI) can also be instrumental in supporting the proper conversion of farmers' responses into standard units by providing a visual interface with the respondents during the interview.

Even with proper conversion factors in hand, there continue to be challenges in the measurement of crop production quantities and/or values. We have already referenced the difficulties for farmers to recall events over periods of several weeks or months. One major complication is due to the fact that many of the poorest smallholders consume the largest share of their production, which thus never reaches the market. As a result, valuation of own-production consumed by the household is particularly challenging, in part due to the fact that farm-gate prices are rarely available in these cases. Lacking farm-gate prices, valuation is generally based on either market prices or unit values derived from the survey by computing an average (or median) value over some geographic area of reference.

Other difficulties result from the fact that large variations in prices frequently occur throughout the year, often due to the fact that when poorer farmers do sell some of their production, they tend to sell low (immediately following the harvest) and buy high (prior to harvest, when stocks have been depleted). Figure 5 below illustrates the issue for Malawi:

compared with better off households, larger shares of poor households tend to buy maize, the main staple food in Malawi, during the lean season when prices are highest. Consequently, estimating total value of production using prices only at one time of the year (i.e., generally post-harvest, when most product is sold and when prices are lower) is likely to bias the estimations. Thus, lack of adequate price data continues to be a hindering factor in the proper estimation of values of production, particularly in relation to the valuation of own production used for consumption.

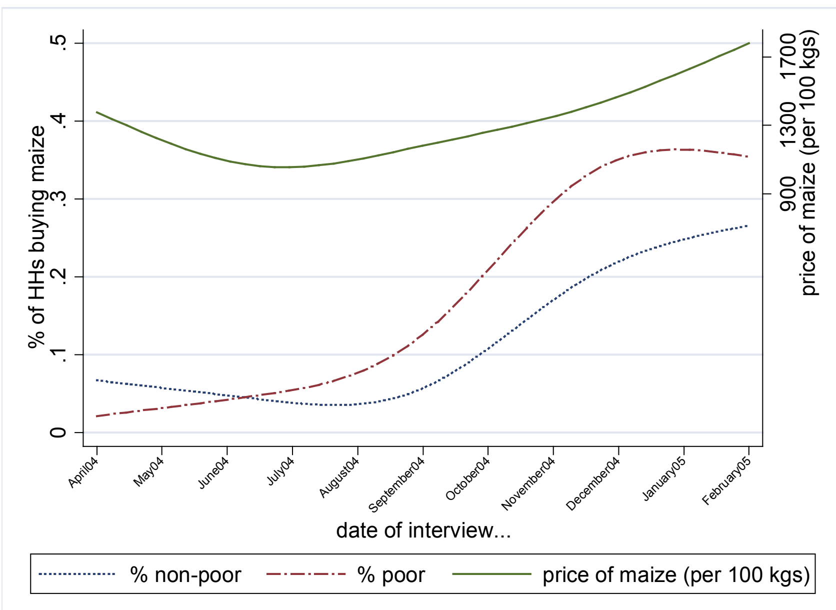

Figure 5: Share of household buying maize, by month and poverty status (Malawi IHS, 2004/05)

Even for the marketed share of production, smallholders seldom keep records of purchases and sales, which could result in an inability to correctly recall these transactions. Beegle et al. (2011), however, demonstrate that in the context of a few African countries and for specific agricultural inputs and crops, farmers' responses do not seem to suffer from large recall biases. Instead, respondents tend to recall information fairly accurately over periods of several months, particularly when questioned about salient, high-value events such as costly fertilizer purchases or the bulk sale of crops, particularly cash crops. Despite these positive findings on the low level of recall error for transactions of staple crops such as maize and cash crops like tobacco, it is difficult to imagine how the same findings would apply to root crops such as cassava and/or continuous crops such as banana.

What then are the options for better quantification of these types of crops, which represent a significant share of total African agricultural output? Some recent research by Deininger et al. (2012) validates the use of harvest diaries *vis à vis* recall methods to estimate crop production. The authors report on the result of a field experiment as part of the 2005/2006 Uganda National Household Survey (UNHS), in which sampled farmers were asked to keep a diary for the entire duration of the agricultural season. Data from the diaries were compared with the recall-based responses given by the same farmers in the course of biannual personal interviews using a structured questionnaire. In almost all cases, farmers' responses based on recall are lower than the diary-based estimates both in terms of number of crops reported and quantities produced. In spite of concerns, respondent fatigue in filling out the diary did not appear to be a major problem. While diaries have some clear potential advantages, the method can be costly and difficult to supervise, which implies concerns about quality. Furthermore, in countries with low literacy and numeracy, keeping diaries may be unfeasible without frequent visits by a local enumerator, thus virtually turning the diary into repeated short recalls. A mobile phone survey of cotton farmers conducted by Dillon (2012) serves as an early attempt to explore ways of collecting continuous data without embedding resident crop card monitors, which could be a way forward. However, in terms of comparing diaries to recall methods, very little additional empirical evidence beyond the Deininger et al. study exists in this area of agricultural statistics.[8]

In terms of quantification of production, crop cutting is often considered the gold standard, but it is more applicable and easier to conduct for cereal crops than for root and/or continuous crops, due to the unpredictable timing of harvest for the latter. Subplots of size ranging from 2x2 meters (generally for cereal) to 5x5 meters (for root crops) are chosen at random from the randomly selected plots of sample households. The procedure is time-consuming and costly, requiring multiple visits from planting to harvest. Due to the high costs involved, the method is not common in large farm and household surveys and is practiced at other times on a selected basis, as in the case of the 2012-13 Agricultural Sample Survey in Ethiopia, where estimates for individual crops at the national and subnational level were generated from five crop cuts in each primary sampling unit (PSU).

Another common problem in estimating crop production is intercropping, which complicates the allocation of different crops to the plot area. The preferred method for handling intercropped plots, though challenging, is to apply a notion of seeding rate to estimate the actual area under cultivation for a particular crop. Easier alternatives include asking the farmer's own assessment of the share of the land allocated to a given crop. Needless to say, different methods result in significant differences in terms of average yields, thus resulting in limited comparability in countries' estimates. This is why yields are often reported only for pure stand crops, or estimates are presented separately for the different cultivation practices. However, for instance, more than one-third of plots in the 2010-2011 Malawi Integrated Household Survey were reported as intercropped, making simply disregarding them in productivity computations problematic.

Turning now to the denominator of a yield measure, land area: according to the FAO, traversing (compass and rope, or compass and tape) is considered the gold standard for land area estimation. However, its implementation is time-consuming and costly. For instance, a study as part of the 2003 pilot of the Uganda Agricultural Census compared land measurement by traversing versus GPS units, and found that the average time use per plot measured was over three hours for traversing, more than three times as much as when GPS technology was employed (Schoning et al., 2005). Due to the significant time involvement, traversing is seldom feasible in the context of large national household surveys.

Another potentially accurate alternative option for land area measurement is the delineation of parcel boundaries by satellite imagery. However, at present this is largely impractical, particularly in tree-dense areas and areas with regular cloud cover, where the ability to produce accurate and timely measures is limited. Furthermore, the spatial and temporal extent of national household surveys generally makes the acquisition and processing of such high resolution imagery still largely prohibitive from a cost standpoint. Another option widely used in routine data collection is based on the “eye estimates” of agricultural extension officers, who are often assigned the impossible task of frequently reporting on newly planted areas for each crop over vast areas with little or no transportation facilities.

The two options which are most commonly used for collecting land area measurement are farmer’s self-reporting and GPS-based area measurement. While widely used, self-reported land area is believed to be imprecise, particularly in land-abundant contexts. There are a number of reasons why self-reports may be subject to measurement error. First, farmers may knowingly overstate or understate their landholdings for strategic reasons if they believe that the information may be used for a purpose such as property taxes or access to a social program.

Second, the natural tendency to round off numbers and provide approximations of land area leads to heaping of the data around discrete values. Geography, particularly the slope of the parcel, can also change the way farmers interpret the land (Keita and Carfagna, 2009). Slope-related effects on area measurement are rooted in the fact that the actual area should be the horizontal projection of the parcel as opposed to the parcel area itself, since plants and trees grow vertically and not perpendicularly to the slope, thus requiring for their growth a vertical cylinder of soil (Muwanga-Zake, 1985; Keita, Carfagna and Mu'Ammar, 2010). The difference between actual area and projection appears to be particularly important for slopes greater than 10 degrees (Fermont and Benson, 2011). Finally, as seen in the case of crop production, an additional cause of error is the common use of nonstandard units, even across different regions within the same country. Table 3, listing the conversion factors for different regions within the country of Nigeria, exemplifies this problem.

Table 3: Zone-specific Conversion Factors into Hectares

	Conversion Factors		
Zone	Heaps	Ridges	Stands
1	0.00012	0.00270	0.00006
2	0.00016	0.00400	0.00016
3	0.00011	0.00494	0.00004
4	0.00019	0.00230	0.00004
5	0.00021	0.00230	0.00013
6	0.00012	0.00001	0.00041

Source: Nigeria, 2010/2011 General Household Survey-Panel

As GPS technology becomes more affordable, accurate and user-friendly, GPS-based area measurement provides a practical alternative to farmer self-reported areas and is increasingly being applied in surveys worldwide. For example, in an assessment of agricultural data collection in Sub-Saharan Africa, Kelly et al. (1995) highlight GPS technology as having the potential to enable land area measurement to become a much less time-intensive and costly exercise. Using field experiments, Keita and Carfagna (2009) indicate that GPS-based area measurement is a reliable alternative to traversing and that 80 percent of the sample plots were measured with negligible error.

Recent empirical evidence based on the 2005/2006 Uganda National Household Survey (UNHS) comparing GPS-based and self-reported measurement of parcel areas also suggests the existence of systematic errors in self-reported parcel areas (Carletto et al., 2013). Specifically, smaller-scale farmers consistently over-report the area of their plots, while the opposite appears to be true for larger holdings. It would thus seem obvious and inexpensive to improve on the current productivity estimates by simply training household survey enumerators and extension officers on the use of GPS units.

Unfortunately, even GPS technology has a number of drawbacks which are yet to be fully resolved. For instance, GPS-based coordinates are subject to known types of measurement error rooted in satellite position, signal propagation, and receivers. Approximate contributions of these factors to the overall position error range from 0.5 to four meters (Hofmann-Wellenhof et al., 2008). On a large plot this may not be substantial, but on a smaller plot, the errors may be significant, thus raising potential questions about the validity of using GPS for very small plots (Keita and Carfagna, 2009).[9] Irrespective of this, from a technical standpoint, areas measured by GPS would be expected to create land data with classical measurement error.

Another problem associated with GPS measurement derives from the failure to measure all plots of sample households. Kilic et al. (2013) in Uganda and Tanzania suggest that systematic bias in missing GPS measurements may be a problem, particularly at high levels of non-random missingness, which is highly associated with the distance of the plot to the dwelling. They argue that careful use of imputation techniques facilitated by the regular collection of self-reported plot area measurements assists in overcoming this limitation and in rendering GPS as a viable alternative.

In summary, productivity measures and other agricultural statistics are highly sensitive to the methods used for their collection. Consequently, the existing lack of consensus on protocols and standards has resulted in agricultural statistics that suffer from uncertain quality, poor comparability, and low credibility.

V. Agricultural statistics in the 21st century: Reversing the tragedy

Knowledge gaps in the area of agricultural statistics remain endemic and the challenges ahead are daunting. Given the importance of the agricultural sector in promoting growth and reducing poverty, improving the availability, quality and policy relevance of agricultural data is of paramount importance, particularly for countries in Africa, which lack fundamental information to inform the design of effective policies. This paper has attempted to highlight a few of the shortcomings of the current system and to offer ideas on how integrated household surveys can contribute to filling these knowledge gaps, particularly in the areas of *methodological validation* and *policy analysis*. We recognize that while integrated surveys are only one of many tools available to researchers and practitioners, with their attendant set of limitations, they are nonetheless an indispensable instrument for gaining an improved understanding of the role of agriculture in poverty reduction and growth.

Due to the neglected state of agricultural statistics today, jumpstarting the renewal process has proven difficult. Reversing this situation will take a concerted effort by individual countries and stakeholders to develop and implement global standards and best practices in agricultural statistics. Initiatives like the Global Strategy, led by FAO, and its ensuing plans of action, are a step in the right direction. However, given the importance of this work to the design and implementation of key policies for the wellbeing of citizens of countries in Africa and elsewhere, we must make rapid progress. The window of opportunity made possible by recent events may close at any time. The digital revolution can assist in offering more efficient and cost-effective ways to capture the complexity of agriculture; the progress made to date with technologies such as Global Positioning Systems (GPS), satellite imagery, Computer Assisted Personal Interviewing (CAPI[10]) and mobile phones leaves room for optimism. Nonetheless, embracing the digital revolution by promoting the use of new technologies without paying requisite attention to the 'analogue' experiences of the past will lead to an inefficient allocation of resources and poor results. The validation of these tools and the applicability of these innovations to African realities must precede any full-fledged scaling-up.

It is undeniable that better agricultural data are needed, but moving from Devarajan's statistical "tragedy" to Kiregyera's statistical "renaissance" (Kiregyera, 2014) will require addressing a number of key issues in a timely manner. Furthermore, reversing the decades of under-investment in agriculture will take an equally protracted effort by individual countries and development partners alike. It is our hope that the combination of a long-term strategy of methodological improvement, capacity building and institutional strengthening with shorter-term goals based on the "quick-wins" and low-cost solutions highlighted in this paper will ultimately lead to better-informed agricultural policies that have the potential to improve the lives of the millions of people involved in the agricultural sector worldwide.

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[1] Comprising about 80 percent of all farms in Africa (FAO, 2009).

[2] FAO uses data provided by the Ministry of Agriculture. In the case of Tanzania, this data comes from the routine data system, that is, the system of data collection through agricultural extension officers. However, the final datasets published by the FAO differ, as FAO introduces assumptions based on a number of factors, including perceived quality of the data received, need for interpolation and extrapolation because of missing data, *inter alia*.

[3] CSA is now in charge of producing and reporting annual estimates of production of the main crops based on the Agricultural Sample Survey. The dramatic increase in yields between 2004 and 2008 were the subject of considerable international controversy, with a major study highlighting the urgent need for validation of the data on cereal production, area cultivated and yields (Dercon et al., 2009).

[4] In some cases, sample-based agricultural censuses based on very large samples are deployed as an alternative to full enumeration. This is the case, for instance, in Tanzania, where a sample-based agricultural census is planned every five years.

[5] For example, as of this writing, a good-quality GPS unit from a respected manufacturer can be purchased for approximately USD 300.

[6] Fortunately, there are also some notable exceptions. For instance, results from the latest Census of Agriculture in Mozambique were released within 6 months.

[7] Conditional on having some positive income from livestock activities.

[8] For some examples on consumption diaries, see Gieseman (1987), Gibson (2002), Battistin (2003), Ahmed et al. (2006), and Beegle, DeWeerdt, Friedman, & Gibson (2010).

[9] Other sources of measurement error resulting from GPS units are linked to topography and canopy cover, as well as to weather conditions at the time of measurement (Keita and Carfagna, 2009).

[10] The LSMS is currently supporting the development of a freeware CAPI system by the Computations Tool team in the Development Research Group of the World Bank. The multi-component application, known at *Survey Solutions*, is available at https://solutions.worldbank.org

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