The Journal of Development Studies, 2016
Vol. 52, No. 9, 1372–1387, http://dx.doi.org/10.1080/00220388.2016.1146703

Routledge
Taylor & Francis Group

When the Data Source Writes the Conclusion: Evaluating Agricultural Policies

SAM DESIERE *, LOTTE STAELENS* & MARIJKE D'HAESE*
*Department of Agricultural Economics, Ghent University, Gent, Belgium

(Final version received October 2015; final version accepted December 2015)

ABSTRACT *Statistics describe realities, but they also shape them, since they are used to design or support policies. As such accurate statistics are important. Using the agricultural sector in Rwanda as a case study, we demonstrate that dubious statistics can spread quickly. According to data from the Food and Agricultural Organization (FAO), yields have increased by 60 per cent since the implementation of large scale agricultural reforms, while other datasets point towards more modest gains. Yet, estimates in line with those of the FAO dominate the official discourse. We suggest that the discrepancies between datasets may be explained by the difficulties of collecting accurate agricultural statistics combined with an incentive to overestimate yields to show that the reforms have worked.*

1. Introduction

Do statistics describe realities or do they create them? These contrasting views are a recurrent theme in social sciences and public debates. On the one hand, data and statistics are considered to be objective observation of facts (Kuhn, 1961; Reiss, 2013). On the other hand, it is recognised that data and statistics are 'man-made' and as such, can be based on questionable assumptions, are shaped by the context in which they were generated and are prone to manipulation. This latter idea was aptly summarised by the Scottish poet Andrew Lang (1844–1912): 'some people use statistics like a drunk uses lamp-posts, more for support than illumination', a quote that was recently repeated by Romani Prodi, a former president of the European Commission (Carletto, Jolliffe, & Banerjee, 2013). In his main work, French historian of statistics and sociologist, Desrosières (2002/1993), elaborates on these contrasting views. He refers to the double role of statistics as being both a social fact and referring to social facts. He argues that statistics and the context which shapes them are intimately linked. This perspective is shared by contemporary researchers in philosophy of science and economic history (Jerven, 2014a; Jerven & Johnston, 2015; Mensink, 2012; Morgan, 2001). In sum, statistics, independent of their evidence base, can become a reality in themselves.

Because statistics describe realities and, at the same time, shape realities there have been confusions and debates about 'truth' in many settings. Regions with limited capacity to assemble good quality data are arguably more vulnerable to the dissemination of biased statistics. Similarly, if collecting accurate data is challenging for technical reasons, the statistics that enter the public arena are more likely to be misleading and possibly biased. Agricultural statistics in sub-Saharan Africa are a case in

Correspondence Address: Sam Desiere, Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Gent, Belgium. Email: sam.desiere@ugent.be
An Online Appendix is available for this article which can be accessed through the online version of this journal available at http://dx.doi.org/10.1080/00220388.2016.1146703

point. Although widely recognised to be of poor quality, they continue to shape policy debates and rural policies (Jerven, 2013; Mosley, 1992; Whitfield, 2012).

This paper shows that the lack of reliable agricultural data contributes to the risk of dubious statistics becoming part of reality. We illustrate this point by using the reporting on agricultural reforms in Rwanda as a case study. We used several datasets to compare agricultural yields in Rwanda before and after the implementation of the Crop Intensification Program (CIP) in 2007–2008. This programme is part of a wider set of policies implemented by the government of Rwanda (GoR) which aims to launch a green revolution. The main objective of the programme was, and continues to be, an increase in yields and food production.

The reforms were considered a great success by the government. Official documents and newspaper articles reported substantial improvements in yields of staple crops (Altazin, 2014; Kalibata & Roy, 2015). Moreover, a regional economic outlook produced by the IMF states 'as a result [of CIP], yields have increased significantly, from being among the lowest to among the highest in Sub-Saharan Africa' (p. 50). This statement includes a figure that shows an increase in cereal yields from slightly below 1000 kg/ha in 2007 to 2000 kg/ha in 2011 (IMF, 2013a). A World Bank report on Rwanda is equally confident about robust growth in its agricultural sector. It asserts that '…between 2006 and 2011, the food outturn increased by 9.8 per cent [per annum], almost double of the 5.4 per cent between 2001 and 2006' (World Bank, 2013, p. 61) and attributes the acceleration in growth rates to the CIP. Yet, both reports fail to discuss the data and methodology behind the numbers. We attempted to replicate their findings.

As we will show in this paper, the increase in yields since the implementation of the agricultural reforms depends on the dataset used to evaluate it: it ranges from an impressive 60 per cent to a modest 10 per cent increase. We argue that it is not possible to make strong statements about the success or failure of the reforms in increasing yields. The problem is not a lack of data availability – the GoR undertook significant and laudable efforts to make their datasets publicly available – but rather that different data sources contradict each other and there is no way of telling which dataset is more reliable. Yet, it is only the figures that show the largest increase of yields that have been taken up in official discourses as illustrated above. Statistics may thus partially have created their own 'reality'.

It is important to note from the outset that this paper does not aim to evaluate the agricultural reforms in Rwanda. Such an evaluation requires a more comprehensive approach – in which an increase in yields and food production is only one aspect. Furthermore, this study does not have a counterfactual design. In other words, we do not know how yields would have evolved without the Crop Intensification Program. We do, however, occasionally refer to the 'impact of the agricultural reforms' when we simply compare yields before and after the implementation of the reforms since this terminology is also used in the official discourse. In no way do we claim to observe the causal impact of the reforms on yields. Rather than evaluating the reforms in Rwanda, this study focuses on the (lack of) quality of agricultural statistics and the risk of using them to support controversial policies. The case of Rwanda is used to demonstrate that this is a real threat.

This paper contributes to the small but growing literature about data quality in sub-Saharan Africa (Beegle, De Weerdt, Friedman, & Gibson, 2012b; Jerven, 2014a; Jerven & Johnston, 2015). As elsewhere in the literature, we demonstrate that, besides data availability, data quality is a serious concern. Most of the literature has focused on the unreliable measurement of GDP (Jerven, 2013, 2014a). We will focus on the agricultural sector, one of the key sectors in developing countries, where data limitations are likely to be even more severe than for other sectors (Carletto, Jolliffe, & Banerjee, 2015). Bookkeeping in the agricultural sector is uncommon because of the subsistence nature of production, while the unique mixed cropping systems pose a challenge to accurately measuring production. We will argue that the difficulties in data collection combined with political incentives to over-estimate production figures may explain the discrepancies in yields between different datasets.

The paper is structured as follows. In the next section, we briefly describe recent agricultural reforms in Rwanda. We then present in detail the different datasets we draw upon in this study. Next, we outline our methodology and define the notion of overall yields, our preferred indicator of successful agrarian transformation. In the results section, we estimate overall yields from every dataset,

followed by comparing the levels and trends of estimated yields from different datasets. In the discussion, we explore two potential explanations for the discrepancies between datasets: the challenges related to collecting agricultural statistics and the political economy of statistics. We conclude by formulating policy implications for Rwanda as well as for the broader community involved in collecting, processing and analysing agricultural data.

2. Agricultural Policy in Rwanda

After the 1994 genocide in Rwanda, a technocratic government took power, which quickly restored relative stability and achieved rapid institutional reconstruction (Reyntjens, 2004). Moreover, it easily managed to attract development aid and Rwanda became one of the donor darlings in the region (Marysse, Ansoms, & Cassimon, 2007). This effort led to a rapid recovery and economic growth averaging 8 per cent in the last decade (Ansoms & Rostagno, 2012). Today, GDP per capita at PPP equals $1486 (IMF, 2013b).

Rwanda is an agriculture-based economy, and the agricultural sector employs more than 80 per cent of the population, accounts for 39 per cent of GDP and is the main earner of foreign exchange. Coffee and, to a lesser extent, tea and sugar cane are the main export products, with coffee accounting for 50 per cent of foreign earnings (GoR, 2009, 2012a). However, the high population density, more than 300 inhabitants/km^2, has posed significant challenges to the agricultural sector for many decades (André & Platteau, 1998; Verwimp, 2013). Competition for land is fierce and the average landholding per household is 0.76 ha, which is often dispersed with most households cultivating approximately four different plots. A quarter of households own less than 0.20 ha of land (GoR, 2010). Soil erosion poses additional and significant threats to soil fertility and undermines the already low levels of agricultural productivity. At the same time, few households have access to fertilisers or improved seeds.

Faced with these challenges, the government of Rwanda (GoR) set out the main priorities for the country's economic development in its ambitious Vision 2020 document. This aims at transforming Rwanda into a middle-income country and shifting away from an agrarian to a knowledge based society by 2020. The development of a market-oriented agricultural sector was one of the main pillars of the Vision 2020 document, which stated that annual growth rates of 4.5–5 per cent in the agricultural sector were essential to overcome poverty (GoR, 2000).

Subsequent official government reports further elaborated on the new agricultural proposals, culminating in the 'organic law determining the use and management of land in Rwanda' signed in 2005 (GoR, 2005). This law encouraged land consolidation with the aim of exploiting increasing returns to scale. For instance, it stipulated that a plot smaller than one hectare cannot be subdivided (GoR, 2005; Pottier, 2006). Moreover, it resumed a process of 'villagisation'. Initially, this policy forced households to abandon and demolish their houses if those houses were situated in areas devoted to agriculture and to rebuild them in the village (Pritchard, 2013). After internal and external protest, the policy was relaxed and nowadays only new houses need to be built within designated areas (Ansoms & Hilhorst, 2014). In addition, the law launched the land tenure regularisation programme that aimed to formally register the land of smallholder farmers to reinforce tenure security (Ali et al., 2014).

The Crop Intensification Program (CIP) was one of the flagship initiatives (GoR, 2015a). It aimed to increase productivity by increasing access to improved seeds and fertilisers to smallholder farmers. Additionally, the GoR selected priority crops and designated areas where those crops should be planted based on the agro-ecological conditions of the area. The underlying rationale is that specialisation, instead of mixed cropping systems, will increase yields, boost exports and facilitate mechanisation in the long term. Hence, farmers were encouraged to plant the same crops as their neighbours within a given area (GoR, 2012c).

3. Data and Methods

3.1. Data

The analyses are based on four datasets. All the datasets contain information about agricultural production, cropped area and yields during different periods from 2005 to 2013 in Rwanda, but differ considerably with regards to the purpose as well as the method of data collection. It is important to note that we have data from before and after the implementation of the agricultural reforms in 2007–2008 in Rwanda.

We grouped the datasets in three categories according to the methodology used: yearly estimates disseminated by the Food and Agricultural Organization (FAO), household surveys and agricultural surveys (Table 1).

The first group of datasets consists of yearly estimates of yields and cropped area of all major crops provided by FAOSTAT. These statistics are collected by FAO from national statistical offices and ministries of agriculture and disseminated through FAO's website. Data is available for most developing countries, including Rwanda, since 1961. The FAO has no mandate to check the reliability of the figures, but simply disseminates the official national statistics (FAO, 2012, 2014). Hence, it would be more correct to refer to this data as 'statistics from the Ministry of Agriculture of Rwanda'. However as it is common practice to refer to them as 'FAO statistics' we will also do so in the remainder of this paper. It should nevertheless be kept in mind that if FAO statistics are unreliable it is because the national ministries reported wrong numbers. It was confirmed by the FAO that data from Rwanda are official government data and are not based on estimates of FAO staff.

The second group of datasets are household surveys. Household surveys follow a pre-defined sample design and collect information through door-to-door interviews. They form the backbone of statistical information in developing countries. We used two representative household surveys, known by their French acronym EICV,[1] which are conducted every five years by the National Institute of Statistics of Rwanda to monitor poverty and living conditions (GoR, 2012b). They include a section on agricultural production and land. Both these key variables are based on recall by the household head. The micro data are freely available from its website. EICV 2 commenced in October 2005 and

Table 1. Overview of the different datasets

Three methodologies	Four datasets	Period	Collected by	Purpose	Sample size
Yearly estimates	FAOSTAT/ Ministry of Agriculture	Yearly since 1961	FAO in collaboration with national statistical offices and ministries of agriculture	Global statistics to monitor worldwide trends	Time series of all major crops
Household surveys	EICV 2 (Enquête Intégrale sur les conditions de vie)	October 2005–2006	National Institute of Statistics in Rwanda (NISR)	Monitoring poverty and living conditions	6900 (2225 valid observations)
	EICV 3 (Enquête Intégrale sur les conditions de vie)	October 2010–2011	National Institute of Statistics in Rwanda (NISR)	Monitoring poverty and living conditions	14,308 (8878 valid observations)
Agricultural survey	Agricultural survey Rwanda	November 2012–September 2013	National Institute of Statistics in Rwanda (NISR)	Comprehensive agricultural statistics for planning; compilation of national accounts	>15,000 (no microdata available)

continued till October 2006. The survey included 6900 households and followed a stratified cluster design (GoR, 2006). After removing households living in urban areas or with incomplete information on land or agricultural production, only 2225 observations remained. EICV 3 (October 2010 to October 2011) used a similar methodology and questionnaire as EICV 2, but the sample was much larger and representative at the district level. The survey contained 14,308 households of which we kept 8878 observations for further analysis (GoR, 2012a, b, d). In Online Appendix A, we discuss in detail the criteria used to discard observations in the datasets. Moreover, we provide evidence that the household characteristics of discarded households do not differ substantially from the included households, although they do differ with regards to their farm size. We argue that missing information on food production occurred randomly and that there is no reason to assume that we discarded or included households with the lowest or highest yields.

The third group of datasets are the agricultural surveys. Agricultural surveys are set up to gather detailed data about agricultural production, land use and yields. In contrast to household surveys, they are more concerned with estimating total production than with household characteristics. This translates into a different sampling design which randomly sampled fields instead of farmers. As agricultural surveys focus on agriculture, much attention is paid to carefully measuring production and land. An agricultural survey was conducted by the National Institute of Statistics of Rwanda from November 2012 to November 2013. More than 15,000 farmers were interviewed during the three agricultural seasons. As the micro data from this survey are not publicly available, we relied upon the numbers reported in the main report of the survey (GoR, 2013).

3.2. Methods

As mentioned earlier, datasets were classified in three categories according to the methodology used (FAOSTAT statistics, household surveys and agricultural surveys). Each category relied upon different approaches to estimate agricultural production, cropped area and yields.

If we want to assess the increase in yields since the agricultural reforms of 2007–2008, it is sufficient to study the trends in yields over time using a similar category of data. This is possible with data from FAOSTAT and the household surveys, for which we have data before and after the implementation of the reforms. It is not possible to examine trends in yields from the agricultural survey as we only have information for one point in time. However, we also want to compare levels of yields across datasets. Comparing levels is more troublesome than trends because it requires a certain degree of equivalence between the datasets. In other words, we assume that, notwithstanding the vastly different methodologies, the datasets measure the same underlying concept related to food production and yields. Only if this assumption holds can the levels of estimated yields be compared between different categories of datasets (Przeworski & Teune, 1966).

To compare levels and trends of yields, we need an indicator that summarises this information from the raw data. Our preferred indicator is 'overall yields', defined as total food production converted into its energy content per hectare. To get a familiar expression of yields, that is in kg/ha, we divided by the calorific content of beans, one of the main staple crops in Rwanda.[2] There are three equivalent approaches to define overall yields that correspond to the three categories of datasets defined earlier. They are formally presented by the following equations:

$$Overall\ yields = \sum_{i=1}^{14} \frac{cal_i}{cal_{beans}} * \frac{A_i}{A_T} * yield_i \qquad (1; \text{FAOSTAT})$$

$$= Median_j \left[\sum_{i=1}^{14} \frac{cal_i}{cal_{beans}} * \frac{production_{ij}}{A_{Tj}} \right] \qquad (2; \text{Household surveys})$$

$$= \sum_{i=1}^{14} \frac{cal_i}{cal_{beans}} * share_i * yield_{i,seasonB} \qquad (3; \text{Agricultural survey})$$

First, overall yields can be defined as a weighted sum of crop-specific yields ($yield_i$), weighted according to the energy content of crop i (cal_i) relative to beans (cal_{bean}) and the share of the crop in the total cropped area ($\frac{A_i}{A_T}$). This is the definition used to analyse the data from FAOSTAT which reports on crop-specific yields and cropped area.

Household surveys estimate total harvest by crop as well as the total landholdings of every household. They do not estimate the share of land devoted to each crop because mixed cropping systems make this very cumbersome. The overall yield of a household, j, is then defined as total aggregate production ($production_{ij}$) expressed in its energy content and divided by landholdings of the household (A_{Tj}). As every farmer is unique, this calculation gives us a distribution of overall yields. This distribution is interesting by itself and will be discussed in depth. Overall yields at the national level are then defined as the median value of the distribution of yields. We opted for the median instead of the mean value of this distribution as a proxy of overall yields because the median is less susceptible to outliers than the mean.

The third equation is used to calculate yields based on data from the agricultural survey. This survey estimates crop-specific yields in every season and the share of land devoted to every crop ($share_i$). We defined overall yields as a weighted average of crop-specific yields in season B (March to July), because this season contributes the most to total annual food production.

To ensure comparability of overall yields between datasets, we selected 14 food crops that were included in all the datasets. This selection included cereals (maize, millet, sorghum, rice, taro and wheat), roots and tubers (cassava, potatoes and sweet potatoes), pulses (beans, peanuts, peas and soybeans) and banana/plantains. According to FAOSTAT, these crops accounted for more than 80 per cent of the total cropped area in Rwanda in 2013. Cash crops, for example, coffee and tea, were not included in the analysis because we focused on food crops and because these were not included in the agricultural survey.

It is important to point out a subtle, yet important, difference in the interpretation of overall yields depending on the definition of 'land' area. We can use two definitions of land: *arable land* or *harvested land. Arable land* is defined as total land cultivated during an agricultural year. *Total harvested land* measures the total land area that has been harvested during a year. Hence, land that is harvested twice a year will be counted twice according to the definition of *total harvested area*, but will only be counted once according to the definition of *arable land*. The distinction between *total arable land* and *total harvested area* is important, because there are three cropping seasons during the agricultural year in Rwanda. The same plot of land is frequently harvested more than once a year. Hence, the *total harvested area* is greater than the *total arable land*. FAOSTAT and the agricultural survey reports the *total harvested area* of every crop. The household surveys, on the other hand, report total landholdings and, hence, *total arable land*. As a result, the household surveys may, if anything, overestimate overall yields. This subtle difference in the definition of land is one example why caution is warranted when comparing estimates of overall yields between different categories of datasets.

Overall yields are a fairly good instrument to evaluate the impact of agricultural reforms for three reasons. First, all stakeholders agree that increasing yields, rather than expanding arable land, is the only way to increase food production since most arable land is already under cultivation in this densely populated country. Second, our indicator of overall yields takes into account all major food crops, but gives more weight to crops that account for a larger share of total cropped area. An increase of yields of frequently cultivated crops, such as beans, therefore has a larger positive impact on overall yields than increasing yields of niche crops such as soybeans. For this reason, focusing on overall yields rather than on crop-specific yields gives a more accurate assessment of the impact of the reforms on growth in the agricultural sector. Third, overall yields are easier to estimate than total food production. Estimating total food production with household surveys requires aggregating the data at national level. Such an aggregation requires accurate sampling weights. Furthermore, it requires that the survey is representative for the agricultural sector, which is not necessarily true since the survey is representative for the population. In addition, data aggregation is more sensitive to outliers in production numbers at household level (for instance, due to data entry errors) than our definition of overall yields.

One important drawback of using yields to evaluate the agricultural reforms is the implicit, underlying assumption that small-scale farmers are profit-maximisers. In reality, small-scale farmers seek a balance between profit maximisation and risk minimisation. A comprehensive evaluation of the agricultural policies should therefore also consider risk. Several scholars have already criticised the reforms because crop specialisation and mono-cropping increases risks for small-scale farmers (Pritchard, 2013; Van Damme, Ansoms, & Baret, 2014). Consequently, if one wants to call the reforms a success, a substantial increase in yields is required to offset the increased riskiness of farming.

4. Results

4.1. Yearly Estimates from FAOSTAT

Figure 1 compares the evolution of overall yields in Rwanda since 1990 based on data from FAOSTAT. It is striking that yields reported by FAO have increased tremendously since 2007–2008, which is generally considered as the start of the implementation of the Crop Intensification Program (GoR, 2012c). According to the FAO overall yields have increased from 1253 kg/ha in 2007 to 2077 kg/ha in 2013. In other words, yields have increased by 66 per cent in six years.[3] Most of this increase occurred from 2007 to 2011, and yields have only increased marginally since then. If these statistics are reliable, the claims that the agricultural reforms in Rwanda are extremely successful are justified.

Examining the FAOSTAT data in more detail reveals that the increase in overall yields is driven by two complementary reasons. The most important one is the increase in yields of all crops since 2007 (Figure 2, left panel). The increase in yields is most pronounced for maize, for which yields have more than tripled since 2005, and for cassava, for which yields have nearly tripled. Both crops are designated as 'priority crops' by the government of Rwanda (GoR, 2012c). Excluding cassava when estimating trends in overall yields reduces the increase in overall yields from 66 per cent to 42 per cent. Excluding both cassava and maize from the estimation, reduces this increase to only 30 per cent. Consequently, the sharp increase in overall yields since 2007 is mainly driven by strong yield growth of cassava and maize. In contrast, yields of beans, the most important staple crop in Rwanda and also one of the priority crops, remained constant. The second, and less important, explanation behind the increase in overall yields, is a shift over time in cropped area towards production of those crops with the greatest increase in yields (Figure 2, right panel).[4] For instance, land cultivated with maize accounted for 8 per cent of the total cropped area in 2007 and this almost doubled to 15 per cent in

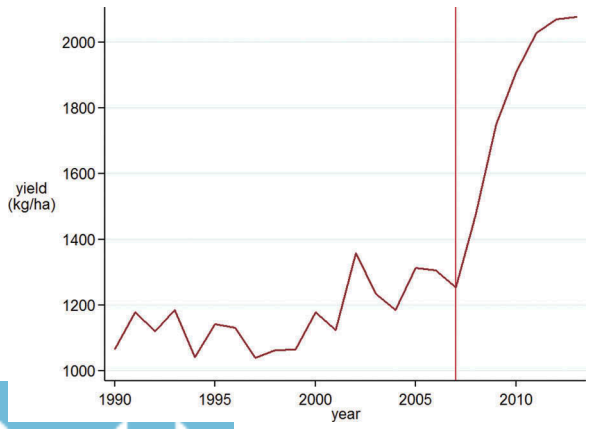

Figure 1. Overall yields since 1990–2013.
Source: FAOSTAT and own calculations.

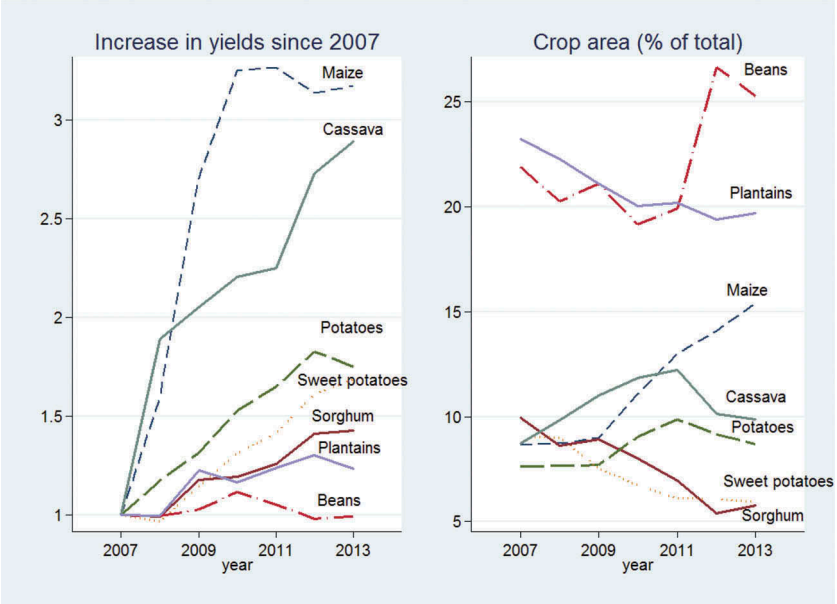

Figure 2. Increase in yields since 2007 (left panel) and share of land devoted to each crop (right panel).
Notes: Only crops cultivated on more than 5 per cent of total cropped area in 2013 are included in the figures. Yields 2007 = 1.
Source: FAOSTAT and own calculations.

2013. The share of land devoted to cassava increased slightly from 2007 to 2013. At the same time, land cultivated with sorghum, sweet potatoes and plantains has decreased over time. Only the evolution of land allocated to beans does not follow this trend since yields of beans remained constant, while land cropped with beans increased from 22 per cent in 2007 to 25 per cent in 2013.

It is interesting to compare the evolution of yields and cropped area between 'priority' and 'non-priority' crops. As part of its agricultural reforms, the government selected six priority crops, namely beans, cassava, potatoes, maize, wheat and rice (GoR, 2012c, 2015a). On average the yields of priority crops have more than doubled since 2007, while yields of non-priority crops have increased by 40 per cent. Similarly, FAOSTAT statistics show a shift in cropped area from non-priority crops towards priority crops. Priority crops accounted for 50 per cent of total cropped area in 2007 and 62 per cent of total cropped area in 2013.

4.2. Household Surveys

Table 2 shows median overall yields in Rwanda in 2006 and 2011 estimated with household survey data. Overall yields in 2011, three to four years after the implementation of the reforms, were only 20 per cent greater than yields in 2006, just before the implementation of the reforms. Household surveys thus point to a more modest increase in yields since the reforms than FAOSTAT-estimates. In sum, the success of the agricultural reforms depends on the data used to evaluate it.

Of the three categories of datasets, only for the household surveys did we have access to the underlying micro data. This allowed us to examine the distribution of yields between households. Figure 3 shows the cumulative distribution of yields in 2006 and 2011 and indicates the median values of the three distributions. The cumulative distributions are remarkably similar. An important feature of the distribution of yields is the enormous variation between farmers. For instance, our results show that 10 per cent of the households in 2011 reported yields of less than 450 kg/ha, while another 10 per cent of the households reported yields greater than 3600 kg/ha. This makes it extremely difficult to determine the 'representative' yield in Rwanda and explains why we preferred median rather than

Table 2. Estimates of overall yields based on household surveys

	Rwanda (2006)	Rwanda (2011)
Median yields (kg/ha)	1140	1370
Number of observations	2225	8878

Source: EICV 2 and EICV 3 and own calculations.

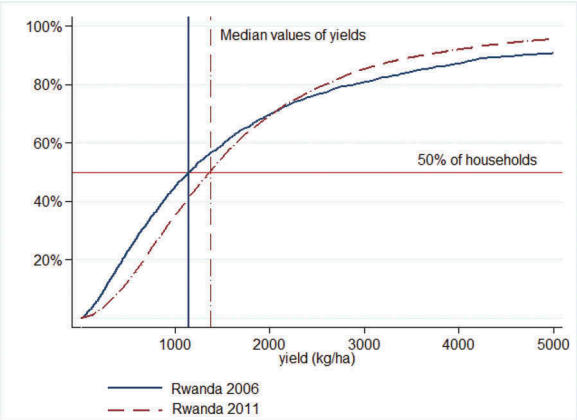

Figure 3. Cumulative distribution of yields in Rwanda in 2006 and 2011 based on household survey data.
Source: EICV 2 and EICV 3 and own calculations.
Notes: Vertical lines indicate median values of yields, horizontal line corresponds with 50 per cent of the households.

mean yields as the best proxy of overall yields in a country. Part of this huge variation is undoubtedly due to measurement errors in both production numbers and cropped area, which were based on farmers' estimates. Nevertheless, it probably also represents part of an agricultural reality. Yields are known to fluctuate significantly because of weather conditions, regional differences in soil quality and differences in inputs of fertiliser and labour. The two other sources of data, that is FAOSTAT-statistics and the agricultural survey, also undoubtedly required making assumptions on the distribution of yields to determine 'average' yields. However, neither FAOSTAT nor the report of the agricultural survey documented the variability of yields or the assumptions made to deal with this variability. This is unfortunate because we need this information to estimate the accuracy (95% confidence intervals) of 'average' yields.

4.3. Agricultural Survey

Using the estimates of crop-specific yields and cropped area in season B of 2013 reported in the final report of the agricultural survey, overall yields were 1478 kg/ha (GoR, 2013, table 72, p. 64 & table 73, p.64). Overall yields in season A and C were 1270 kg/ha and 1344 kg/ha, respectively. Consequently, our estimate of overall yields of 1478 kg/ha is an upper bound of average 'annual' overall yields. This estimate is slightly higher than overall yields estimated with household survey data, but still well below the FAO-estimate of 2077 kg/ha.

The reasons behind the discrepancy between both estimates are explored in Table 3. The table directly compares crop-specific yields and cropped area as reported by FAO and the agricultural survey. FAO-based estimates of yields of all crops are greater than those reported by the agricultural survey. This is especially the case for cassava, for which yields differ by a factor of five. Yields of maize and potatoes are also substantially greater according to FAOSTAT, by 33 per cent and 40 per

Table 3. Differences in yields and cropped area between FAOSTAT and the agricultural survey

	Yields (kg/ha)		
	Agricultural survey	FAO	Ratio (FAO/Agricultural survey)
Bananas[a]	8465	9223	1.09
Beans	853	913	1.07
Cassava	3176	15,766	4.96
Maize	1712	2285	1.33
Potatoes	9709	13,606	1.40
Sorghum	1355	1443	1.07
Sweet potatoes	8,147	9,616	1.18

Source: Report agricultural survey 2013, season B (GoR, 2013: table 72, p. 64 & table 73, p.64) and FAOSTAT.
Notes: Only crops accounting for more than 5 per cent of total cropped area (using FAO-estimates) in 2013 are reported. [a]The agricultural survey makes a distinction between bananas for cooking, beer or fruit, while FAO makes no such distinction. We reported yields of 'banana for cooking'.

cent respectively. The discrepancy between overall yields estimated by the FAO (2077 kg/ha) or the agricultural survey (1478 kg/ha) is mainly caused by three crops: cassava, maize and sweet potatoes.

5. Comparing Agricultural Yields in Rwanda between Datasets and over Time

Table 4 summarises the main findings of this paper. It shows estimates of 'overall' yields, which take into account all the important crops in Rwanda weighted according to their share of total cropped area. We estimated overall yields from three different data sources: yearly FAOSTAT estimates, household surveys and an agricultural survey.

The evolution of yields since the implementation of the reforms in 2007 can be assessed using these estimates of overall yields. The increase in yields is very different according to the dataset, albeit always positive. According to the FAO, yields increased by 55 per cent between 2006 and 2011, while household surveys point to a 20 per cent increase over the same period.

Comparing estimates of overall yields between datasets using very different methodologies requires more care because the different data sources used different methodologies to measure the same underlying concept. Nevertheless, a comparison of overall yields between data sources can provide us with additional insights. This comparison reveals large discrepancies of overall yields between different datasets. Estimates based on FAO-statistics and household surveys were rather similar in 2006. In 2011, however, overall yields estimated with FAO-statistics and household surveys differed by 50 per cent. The agricultural survey tends to confirm the estimates from the household surveys as more realistic. This suggests that the estimates of the FAO have been too optimistic since 2007, when the agricultural reforms were introduced.

Table 4. Overall yields (kg/ha) in Rwanda estimated with different data sources

	Yields (kg/ha)		
Year	FAO	Household surveys	Agricultural survey[a]
2006	1,306	1,140	
2011	2,029	1,370	
2013	2,077		1,478

Notes: [a]only season B (March to end of July)

Finally, we examined whether other publicly available statistics about Rwanda can be reconciled with our finding of weaker yield growth than predicted by the FAO. More specifically, we looked at growth in fertiliser application, trends in food imports and the evolution of poverty rates. None of these statistics in themselves can rule out a 66 per cent increase in overall yields as predicted by the FAO. Taken together, however, they do tend to suggest that FAO's prediction is too optimistic.

The Government of Rwanda points towards the strong increase in fertiliser imports since 2007 to explain strong yield growth. According to official statistics, fertiliser imports quadrupled from 8000 tonnes prior to the implementation of CIP to 35,000 tonnes in 2012 (GoR, 2014, 2015b; Monitor Group, 2013). Such a strong increase in fertiliser use could indeed explain the strong yield growth as reported by the official statistics. These figures are, however, contradicted by estimates based on the household surveys and the agricultural survey. The household surveys show that the number of households applying fertiliser increased from 16 per cent in 2006 to 34 per cent in 2011. The agricultural survey tends to confirm these statistics. Detailed results are provided in Online Appendix B. It is striking that the different data sources are internally consistent. If the official figures of increasing fertiliser imports are reliable, yield growth predicted by FAOSTAT seems plausible. If, on the other hand, fertiliser use reported by the household surveys and the agricultural survey are considered the most reliable data sources, FAOSTAT's prediction of yield growth seems misguided. Hence, depending on the data source, statistics on fertiliser use confirm or refute our finding of less impressive yield growth than predicted by the FAO.

A second, indirect, approach to check the reliability of our findings is by examining trends in food imports in Rwanda. One would expect decreasing net food imports with increasing food production. This is not confirmed by FAOSTAT statistics. Imports of cereals, particularly maize, decreased from 133,000 tonnes in 2007 to 77,000 tonnes in 2008, but have recovered rapidly since 2008, reaching 238,000 tonnes in 2011.[5] These figures are difficult to reconcile with the sharp increase in food production as predicted by the FAO. This suggests that FAOSTAT may over-estimate total food production, although other factors such as population growth and economic growth may also partially explain growing food imports.

The GoR is often praised by international donors for its sharp reduction in poverty rates. Poverty decreased from 57 per cent in 2006 to 45 per cent in 2011 (Ansoms & Rostagno, 2012; Desiere, Vellema, & D'Haese, 2015; GoR, 2012b). These figures were estimated with the household surveys EICV 2 and EICV 3 that were also used in this study. Although we cannot tell whether these poverty estimates are reliable, we can examine if this reduction can be reconciled with our estimate of yield growth. It is well established that growth in the agricultural sector significantly reduces poverty. Typically, one finds that a 1 per cent increase in yields decreases poverty by between 0.5 per cent and 2 per cent (Datt & Ravallion, 1998; Irz, Lin, Thirtle, & Wiggins, 2001; Thirtle, Lin, & Piesse, 2003). Consequently, a modest increase of yields of between 10 per cent and 40 per cent between 2006 and 2011 in Rwanda is already sufficient to decrease poverty by 20 per cent. Hence, our estimate of yield growth based on the household surveys (+20%) does not rule out a poverty reduction from 57 per cent in 2006 to 45 per cent in 2011 as is claimed by the GoR.

6. Discussion

This study does not take a definitive stance on the success or failure of the agricultural reforms in Rwanda. The results are inconclusive, and our findings can easily be criticised by arguing that household surveys are just not well adapted to measuring yields. This is indeed partly true. Yet, we believe that there is no reason to assume that FAOSTAT statistics are any closer to the 'truth' than household surveys or the agricultural survey. What we intend to show in this study is that different datasets lead to different conclusions, and this raises several questions.

A first pressing question is why the FAO-numbers, which represent the official statistics of the GoR, are probably overestimating yields in Rwanda. There are two possible explanations for this: the challenges related to collecting accurate agricultural statistics and the political economy of agricultural data.

Even with dedicated agricultural surveys in the best performing agricultural statistical offices in Africa, collecting reliable agricultural statistics is still challenging (Jerven, 2013; Vandercasteelen, Dereje, Minten, & Taffesse, 2013). The main reason is the predominance of subsistence agriculture in Africa. This limits the need for bookkeeping and explains why estimates of production in surveys often rely on recall by the household head (Beegle, Carletto, & Himelein, 2012a). This can cause inaccurate numbers. Deininger, Carletto, Savastano, and Muwonge (2012), for instance, report that recall underestimates production by 40 per cent compared to record keeping in diaries. Moreover, mismeasurement may be more pronounced for some crops than for others. It is, for instance, well known that obtaining reliable production numbers for roots and tubers, such as cassava, is especially difficult. In contrast to high-value crops, cassava is harvested in small quantities over several months because it stores better in the ground. In addition, cassava is often only fully harvested during times of food crisis (Carletto et al., 2015). Perhaps, these difficulties explain why FAOSTAT-estimates of yields of cassava (15 ton/ha) are five times greater than those of the agricultural survey (3 ton/ha). An additional challenge in Rwanda is the fact that most crops are grown in mixed cropping systems. This makes it extremely difficult to accurately estimate the share of land devoted to each crop (Fermont & Benson, 2011).

Although gathering reliable data is difficult, this does not yet explain why, according to FAO, yields have increased substantially since 2007. The FAO confirmed that the figures were provided by the Ministry of Agriculture of Rwanda as is standard practice (FAO, 2006; World Bank, United Nations and Food and Agricultural Organization, 2010).[6] As such, the sharp increase in yields since 2007 may be explained by a political economy argument (Sandefur & Glassman, 2015). The increase in yields coincides with the implementation of agricultural reforms in Rwanda and officials may have had an incentive to over-estimate agricultural production to demonstrate that their reforms were working. For instance, the increase of yields was the largest for maize (+200% since 2007), which is one of the 'priority' crops of the government. More generally, we found that yields of priority crops have increased more than yields of non-priority crops. Local officials in Rwanda are bound by performance contracts that specify development targets and are set by the national government in line with national policies (Ansoms, 2008; Ingelaere, 2010). Local officials who do not succeed in achieving their targets miss out on promotions and may even get fired for below average performance (Versailles, 2012). This provides a strong incentive to tweak the numbers.

Yet, this raises a new question: why are yields of the main staple crops reported in the agricultural survey, which was conducted by the National Institute of Statistics of Rwanda in collaboration with the Ministry of Agriculture, much lower and probably more realistic? Why did officials charged with data collection not overestimate yields in this case? The answer may lie in the way the data were collected which determines how easily numbers can be 'negotiated'. As Jerven (2014b) argues, when the empirical evidence is weak, there is ample room for a negotiation about agricultural data. Although we have no proof, FAO's numbers are likely to be based on eye-estimates by local extension officers of cropped area and total harvest, which is common practice in many countries (Carletto et al., 2015). Eye-estimates are known to be very inaccurate and can, therefore, more easily be tweaked to satisfy political objectives. It is not even necessary that this manipulation occurs consciously, it is already sufficient that officials in charge of data reporting simply believe that the agricultural reforms work and, hence, overstate production numbers. For instance, as the import of fertilisers was widely reported to have surged because of the CIP (by more than 32% per annum by one account), officials may have expected a substantial increase in yields and food production (Druilhe & Barreiro-Hurlé, 2012; Monitor Group, 2013). An agricultural survey, on the other hand, follows a pre-defined, 'scientific' design and is considered to be the gold standard for collecting reliable agricultural data (Fermont & Benson, 2011). As a result, numbers from agricultural surveys may be more

'trusted' and are less susceptible to (unconscious) manipulation. A better understanding into the interplay between 'trust in data quality' and political pressure to use numbers to prove that policies are working is an interesting avenue for further research.

7. Conclusion

Our findings have several implications for policymakers in Rwanda and all actors involved in collecting, processing and analysing agricultural data. First, a careful evaluation of the impact of the agricultural reforms in Rwanda on yields remains important because an increase in yields and food production is the main objective of the programme. As these reforms have already been criticised for many other reasons including their top-down approach, increasing social tensions in local communities and reducing tenure security and food security at household level (Ansoms, 2008, 2010; Pritchard, 2013), a strong, positive impact on yields and food production is required to justify the implementation of the programme and to push the reforms even further. Second, agriculture still accounts for the lion's share of the national economy in Rwanda. Reliable agricultural data are thus a condition *sine qua non* for accurate national accounts, which, in turn, are important to monitor growth.

The reliability and accuracy of FAO-numbers and agricultural statistics in Africa have already been criticised by many authors (Devarajan, 2013; Jerven, 2013), including by the FAO and the World Bank themselves (World Bank et al., 2010). This is confirmed by this study, which suggests that FAO numbers in Rwanda are too optimistic and may even be plainly wrong. The danger is that these numbers, rather than those of the household survey or the agricultural survey, get embedded within the FAO's international system of data management and will be taken up over and over again for new analyses (for example, in cross-country regressions, see Woods [2014]). In any case, we should ensure that statistics describe realities and avoid at all cost them becoming a reality on their own. One factor that augments this risk is the lack of clear documentation which provides all the necessary details about how, for which purpose and by whom the FAO numbers were collected. In this respect, we can only join the call of other researchers concerned about data quality to increase the transparency of the data collection process (Jerven, 2013). Fortunately, several institutional initiatives are currently already under way to improve the quality of agricultural statistics in developing countries (Addinson et al., 2015; Chen, Fonteneau, Jütting, & Klasen, 2013; FAO, 2012; World Bank et al., 2010).

Acknowledgements

We would like to thank two anonymous reviewers for their valuable suggestions on previous versions of this paper. All the data used in this paper is publicly available. The FAOSTAT data can be downloaded from their website: http://faostat.fao.org/. The data from the household surveys in Rwanda (EICV 2 and 3) are available from http://microdata.statistics.gov.rw/index.php/catalog. The Stata code used to analyse the data is available upon request from the authors.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. EICV: Enquête Intégrale sur les Conditions de Vie.
2. It is common practice to aggregate total food production by adding up the calorific values of all food crops. For instance, the well known 'Daily per-capita energy supply' indicator of FAO uses this approach (Smith, 1998). We then divided total aggregated production in its energy content by the energy content of beans, one of the main staple crops in Rwanda, to get a familiar expression of yields, that is, expressed in kg/ha. This normalisation facilitates interpretation of the results, but does not influence the findings. This approach is similar to the well-known conversion to cereal equivalents (Rask & Rask, 2014).

A second, common approach to aggregate food production is to convert total production into monetary value. We did not opt for this approach because we did not have good price data. Moreover, this approach requires tricky assumptions about inflation and regional differences in price levels.

3. As a robustness check, we calculated the evolution of total food production using FAOSTAT statistics. Results showed that total food production has increased even more since 2007 (by 92%) than overall yields (66%). This increase was driven by a sharp increase in cassava and maize production. Detailed results are available upon request.
4. To evaluate which of these two factors (that is an increase in crop-specific yields or a shift towards crops with the largest increase in yields), contributed most to the total increase in yields, we calculated overall yields in 2013 keeping the share of land devoted to each crop constant at 2007 levels. This calculation revealed that yields still increased by 60 per cent from 1253 kg/ha to 2022 kg/ha. Hence, the increase in crop-specific yields is by far the most important factor explaining the increase of overall yields.
5. More detailed results are available upon request.
6. A second approach used by FAO to estimate yields is model-based, meaning that yields are predicted based on observable variables such as weather patterns, fertiliser use or population growth. It seems very unlikely that this was the case for Rwanda, given the large increase in yields since 2007.

ORCID

Sam Desiere http://orcid.org/0000-0001-7167-8466

References

Addinson, C., Boto, I., & Mofolo, L. (2015). *Briefing nr. 40. Data: The next revolution for agriculture in ACP countries*. Brussels: Brussels rural development briefings.

Ali, D. A., Deininger, K., & Goldstein, M. (2014). Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda. *Journal of Development Economics*, *110*, 262–275. doi:10.1016/j.jdeveco.2013.12.009

Altazin, Y. (2014, March 4). Les paysan exclus du succès économique rwandais (idées). *Le monde*.

André, C., & Platteau, J.-P. (1998). Land relations under unbearable stress: Rwanda caught in the Malthusian trap. *Journal of Economic Behavior & Organization*, *34*(1), 1–47. doi:10.1016/S0167-2681(97)00045-0

Ansoms, A. (2008). Striving for growth, bypassing the poor? A critical review of Rwanda's rural sector policies. *The Journal of Modern African Studies*, *46*, 1–32. doi:10.1017/S0022278X07003059

Ansoms, A. (2010). Views from below on the pro-poor growth challenge: The case of rural Rwanda. *African Studies Review*, *53* (2), 97–123. doi:10.1353/arw.2010.0037

Ansoms, A., & Hilhorst, T. (2014). *Losing your land: Dispossession in the Great Lakes*. Suffolk: James Currey.

Ansoms, A., & Rostagno, D. (2012). Rwanda's Vision 2020 halfway through: What the eye does not see. *Review of African Political Economy*, *39*, 427–450. doi:10.1080/03056244.2012.710836

Beegle, K., Carletto, C., & Himelein, K. (2012a). Reliability of recall in agricultural data. *Journal of Development Economics*, *98*(1), 34–41. doi:10.1016/j.jdeveco.2011.09.005

Beegle, K., De Weerdt, J., Friedman, J., & Gibson, J. (2012b). Methods of household consumption measurement through surveys: Experimental results from Tanzania. *Journal of Development Economics*, *98*(1), 3–18. doi:10.1016/j.jdeveco.2011.11.001

Carletto, C., Jolliffe, D., & Banerjee, R. (2013). *The emperor has no data! Agricultural statistics in Sub-Saharan Africa*. Washington, DC: World Bank.

Carletto, C., Jolliffe, D., & Banerjee, R. (2015). From tragedy to renaissance: Improving agricultural data for better policies. *The Journal of Development Studies*, *51*(2), 133–148. doi:10.1080/00220388.2014.968140

Chen, S., Fonteneau, F., Jütting, J., & Klasen, S. (2013). *Towards a post 2015 framework that counts: Aligning global monitoring demand with national statistical capacity development* (PARIS21 Discussion Paper Series). Paris: PARIS 21.

Datt, G., & Ravallion, M. (1998). Farm productivity and rural poverty in India. *The Journal of Development Studies*, *34*(4), 62–85. doi:10.1080/00220389808422529

Deininger, K., Carletto, C., Savastano, S., & Muwonge, J. (2012). Can diaries help in improving agricultural production statistics? Evidence from Uganda. *Journal of Development Economics*, *98*(1), 42–50. doi:10.1016/j.jdeveco.2011.05.007

Desiere, S., Vellema, W., & D'Haese, M. (2015). A validity assessment of the Progress out of Poverty Index (PPI)™. *Evaluation and Program Planning*, *49*, 10–18. doi:10.1016/j.evalprogplan.2014.11.002

Desrosières, A. (2002/1993). *The politics of large numbers: A history of statistical reasoning*. Cambridge, MA: Harvard University Press.

Devarajan, S. (2013). Africa's statistical tragedy. *Review of Income and Wealth*, *59*, S9–S15. doi:10.1111/roiw.2013.59.issue-s1

Druilhe, Z., & Barreiro-Hurlé, J. (2012). *Fertilizer subsidies in Sub-Saharan Africa* (ESA Working Paper). Rome: FAO.

FAO. (2006). *Independent external evaluation of the FAO: Inception report submitted to the Council Committee for the Independent External Evaluation (CC-IEE) by the Independent External Evaluation Core Team*. Rome: Author.

FAO. (2012). *Action plan of the global strategy to improve agricultural and rural statistics*. Rome: Author.

FAO. (2014). *Reference manual: An insight into CountrySTAT- food and agriculture data network*. Rome: Author.
Fermont, A., & Benson, T. (2011). *Estimating yield of food crops grown by smallholder farmers*. Washington, DC: International Food Policy Research Institute.
GoR. (2000). *Vision 2020*. Kigali: Ministry of Finance and Economic Planning.
GoR. (2005). *Organic law determining the use and management of land in Rwanda (N° 08/2005 of 14/07/2005)*. Kigali: Official Gazette of the Republic of Rwanda.
GoR. (2006). *Preliminary Poverty Update Report: Integrated living conditions survey 2005/06*. Kigali: National Institute of Statistics of Rwanda.
GoR. (2009). *Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II (PSTA II) Final report*. Kigali: Ministry of Agriculture and Animal Resources.
GoR. (2010). *National Agricultural Survey 2008 (NAS 2008)*. Kigali: Ministry of Agriculture and Animal Resources.
GoR. (2012a). *EICV 3: Thematic report Agriculture*. Kigali: National Institute of Statistics of Rwanda.
GoR. (2012b). *The evolution of poverty in Rwanda from 2000 to 2011: Results from the household surveys (EICV)*. Kigali: National Institute of Statistics of Rwanda.
GoR. (2012c). *Farm land use consolidation in Rwanda: Assessment from the perspective of agriculture sector*. Kigali: Ministry of Agriculture and Animal Resources.
GoR. (2012d). *The third integrated household living conditions survey (EICV3)*. Kigali: National Institute of Statistics of Rwanda.
GoR. (2013). *Seasonal agricultural survey report 2013*. Kigali: Ministry of Agriculture and Animal Resources.
GoR. (2014). *National fertilizer policy*. Kigali: Ministry of Agriculture and Animal Resources.
GoR. (2015a). *Crop Intensification Program (CIP)*. Kigali: Ministry of Agriculture and Animal Resources (MINAGRI). Retrieved from http://www.minagri.gov.rw/index.php?id=618
GoR. (2015b). *Privatized fertilizer importation and distribution system in Rwanda: Contribution to boosting productivity*. Kigali: Ministry of Agriculture and Animal Resources.
IMF. (2013a). *Regional economic outlook: Sub-Saharan Africa keeping the pace*. Washington, DC: Author.
IMF. (2013b). *World economic outlook: Rwanda economic overview*. Washington, DC: Author.
Ingelaere, B. (2010). Peasants, power and ethnicity: A bottom-up perspective on Rwanda's political transition. *African Affairs*, *109*, 273–292. doi:10.1093/afraf/adp090
Irz, X., Lin, L., Thirtle, C., & Wiggins, S. (2001). Agricultural productivity growth and poverty alleviation. *Development Policy Review*, *19*, 449–466. doi:10.1111/dpr.2001.19.issue-4
Jerven, M. (2013). *Poor numbers: How we are misled by African development statistics and what to do about it*. Ithaca, NY: Cornell University Press.
Jerven, M. (2014a). Measuring African development: Past and present. Introduction to the Special Issue. *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, *35*, 1–8. doi:10.1080/02255189.2014.876617
Jerven, M. (2014b). The political economy of agricultural statistics and input subsidies: Evidence from India, Nigeria and Malawi. *Journal of Agrarian Change*, *14*, 129–145. doi:10.1111/joac.2014.14.issue-1
Jerven, M., & Johnston, D. (2015). Statistical tragedy in Africa? Evaluating the data base for African Economic Development. *The Journal of Development Studies*, *51*, 111–115. doi:10.1080/00220388.2014.968141
Kalibata, A., & Roy, A. (2015, February 19). The fertile roots of Rwanda's green revolution (opinion). *The Guardian Online*. Retrieved from http://www.theguardian.com/global-development/2015/feb/19/rwanda-africa-green-revolution-fertiliser-mdgs
Kuhn, T. S. (1961). The function of measurement in modern physical science. *Isis*, *52*, 161–193. doi:10.1086/349468
Marysse, S., Ansoms, A., & Cassimon, D. (2007). The aid 'darlings' and 'orphans' of the Great Lakes region in Africa. *The European Journal of Development Research*, *19*, 433–458. doi:10.1080/09578810701504453
Mensink, J. (2012). *Poverty measures: From production to use*. London: London School of Economics and Political Science.
Monitor Group. (2013). *The business case for investing in the import and distribution of fertilizer in Rwanda*. Kigali: Ministry of Agriculture and Animal Resources.
Morgan, M. S. (2001). Making measuring instruments. *History of Political Economy*, *33*(Suppl 1), 235–251. doi:10.1215/00182702-33-Suppl_1-235
Mosley, P. (1992). Policy-making without facts: A note on the assessment of structural adjustment policies in Nigeria, 1985–1990. *African Affairs*, *91*, 227–240.
Pottier, J. (2006). Land reform for peace? Rwanda's 2005 land law in context. *Journal of Agrarian Change*, *6*, 509–537. doi:10.1111/joac.2006.6.issue-4
Pritchard, M. F. (2013). Land, power and peace: Tenure formalization, agricultural reform, and livelihood insecurity in rural Rwanda. *Land Use Policy*, *30*(1), 186–196. doi:10.1016/j.landusepol.2012.03.012
Przeworski, A., & Teune, H. (1966). Equivalence in cross-national research. *Public Opinion Quarterly*, *30*, 551–568. doi:10.1086/267455
Rask, K., & Rask, N. (2014). *Measuring food consumption and production according to resource intensity: The methodology behind the cereal equivalent approach*. Worcester, MA: College of the Holy Cross.
Reiss, J. (2013). *Philosophy of economics: A contemporary introduction*. London: Routledge.
Reyntjens, F. (2004). Rwanda, ten years on: From genocide to dictatorship. *African Affairs*, *103*, 177–210. doi:10.1093/afraf/adh045

Sandefur, J., & Glassman, A. (2015). The political economy of bad data: Evidence from African Survey and administrative statistics. *The Journal of Development Studies*, *51*, 116–132. doi:10.1080/00220388.2014.968138

Smith, L. C. (1998). Can FAO's measure of chronic undernourishment be strengthened? *Food Policy*, *23*(5), 425–445. doi:10.1016/S0306-9192(98)00049-9

Thirtle, C., Lin, L., & Piesse, J. (2003). The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development*, *31*(12), 1959–1975. doi:10.1016/j.worlddev.2003.07.001

Van Damme, J., Ansoms, A., & Baret, P. V. (2014). Agricultural innovation from above and from below: Confrontation and integration on Rwanda's Hills. *African Affairs*, *113*, 108–127. doi:10.1093/afraf/adt067

Vandercasteelen, J., Dereje, M., Minten, B., & Taffesse, A. S., 2013. *Scaling-up adoption of improved technologies: The impact of the promotion of row planting on farmers' teff yields in Ethiopia* (LICOS Discussion Paper Series No. 344). Leuven: KU Leuven.

Versailles, B. (2012). *Country learning notes: Rwanda: Performance contract (imihigo)*. London: Overseas Development Institute (ODI).

Verwimp, P. (2013). *Peasants in power: The political economy of development and genocide in Rwanda*. Dordrecht: Springer.

Whitfield, S. (2012). Evidence-based agricultural policy in Africa: Critical reflection on an emergent discourse. *Outlook on Agriculture*, *41*, 249–256. doi:10.5367/oa.2012.0101

Woods, D. (2014). The use, abuse and omertà on the "noise" in the data: African democratisation, development and growth. *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, *35*, 120–135. doi:10.1080/02255189.2014.873021

World Bank. (2013). *Rwanda economic update: Maintaining momentum with a special focus on Rwanda's pathway out of poverty*. Kigali: Author.

World Bank, United Nations and Food and Agricultural Organization. (2010). *Global strategy to improve agricultural and rural statistics*. Washington, DC: Author.