
# Are CAPI based surveys a cost-effective and viable alternative to PAPI surveys? Evidence from agricultural surveys in Tanzania and Uganda.

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## ABSTRACT

As the world embarks in a major effort to achieve the Sustainable Development Goals, there is a high demand for high quality and timely agricultural statistics in order to design and implement effective policies, allocate investments, monitor and evaluate progress. Most of the Governments in developing countries are thus searching for cost-effective methods of collecting high quality data on agriculture. Literature from small surveys conducted by research institutes suggest that using Computer Assisted Personal Interview (CAPI) technologies could be a cost effective alternative to the traditional Paper and Pen Interview (PAPI) method. Additionally, there is preliminary evidence that CAPI can improve data quality, shorten interview duration, and that enumerators prefer CAPI to PAPI. As National Statistical Systems (NSSs) operate in a very different context from research institutes and the applicability of these findings are limited. This paper analyses paradata on cost, interview duration, data quality, and enumerator feedback on various surveys conducted by National Statistical Systems (NSSs) in Uganda and Tanzania. The results confirm that CAPI is cost-effective across multiple surveys. Statisticians in Uganda also indicated there were an increase in data quality after using CAPI. Additionally, data from a questionnaire administered to enumerators in both countries showed that they indeed prefer CAPI over PAPI. The analysis of interview duration did not indicate that CAPI interviews are shorter, but this is likely due to factors other than the survey instrument.

**Keywords:** CAPI, National Statistical Systems, Data collection, Surveys

## 1. Background and Introduction

January 1st, 2016 marked the official beginning of the 2030 Sustainable Development Agenda agreed upon by leaders from all over the world in September 2015. The Sustainable Development Agenda (SDA) defines 17 Sustainable Development Goals (SDGs) that promote sustainable economic growth, elimination of poverty and inequality, and address a host of social needs. Under these goals there are 169 individual targets. The SDGs will be monitored by indicators developed by the Inter Agency and Expert Group on SDG Indicators (IAEA-SDGs) and then agreed upon by the UN Statistical Commission. It is anticipated that 2 indicators will be assigned to each target creating approximately 338 indicators (United Nations 2016).

The National Statistical Systems (NSSs) are the natural sources of information for producing the data needed for the SDG indicators. With such a large suite of indicators, it is apparent that there will be a substantial cost of collecting this data and ensuring that it is timely and reliable. The burden is particularly high on NSSs in developing countries that face resource constraints. Accordingly, any cost-savings tools for data collection would be advantageous to the SDG process.

A large share of the cost of data collection traditionally carried out using Pen and Paper Interivewing (PAPI) relates to the printing of the questionnaire itself, transporting them to and from the field, as well as transferring the data into a digital format so it can be analysed, and storing the completed questionnaires. Computer Assisted Personal Interviewing (CAPI) tools which collect data using electronic devices completely eliminate some of these costs. However, the adoption of CAPI has been slow, due to concerns about the fixed cost of equipment, reorganization of statistical processes, and training, quality of technology, lack of Internet connectivity, human capacity and resistance to change. Indeed, there is so far little systematic evidence on the advantages of using CAPI over PAPI to collect data for official statistics.

By using paradata provided by the Ugandan Bureau of Statistics (UBOS), the National Bureau of Statistics of Tanzania (NBS), and the Ministry of Agriculture, Livestock and Fisheries (MALF) of Tanzania on various surveys conducted using CAPI and PAPI, this paper analyses the differences in implementing CAPI and PAPI based surveys across four dimensions: cost, interview duration, data quality, and enumerator opinion. The paper aims at assisting survey managers in developing countries to take a decision on whether to invest in CAPI. Results, however, should be taken with caution as equipment and training cost have been constantly declining in recent years and an ever-growing number of devices and user-friendly software are being marketed and, in some cases, are freely available.

## 2. Literature review and previous findings

The literature comparing CAPI and PAPI survey methods in developing countries is restricted mostly to small sample surveys carried out by research institutes. As NSSs face very different contexts than research institutes, the findings may be of limited use. However, an overview of the main results relating to costs, interview duration, data quality, and enumerator opinion is informative.

### 2.1 Cost

It is well established that, there is a high fixed cost of switching to CAPI due to the purchase of equipment such as tablets or smartphones, servers for data storage, etc. However, there are also savings generated from the reduction or elimination of some variable costs including double data entry, paper storage costs, less data cleaning resulting from higher quality data, and elimination of printing costs (Zhang, et al 2012; King, et. al 2013, Leisher 2014). Caeyers, et. al (2010) found that the break-even number of interviews where the reduction of variable costs associated with PAPI by using CAPI equals the fixed costs of purchasing equipment was 4,000 interviews. Accordingly, surveys with sample sizes below 4,000 respondents would be more expensive using CAPI, but it would be cost-effective for larger samples. Note that this assumes the equipment is only used for one survey. If the fixed cost of the equipment were to be spread over more surveys, this break-even point would certainly decline. Also, the prices of electronic devices that can be used for CAPI have declined greatly in recent years, which would cause this number to decline further. This suggests that CAPI becomes cost-effective after some threshold, and surveys conducted on large sample sizes will benefit more from CAPI. That said, an issue is whether this trend holds for even larger census size samples as substantially more equipment is needed.

### 2.2 Interview duration

Shorter interviews result in lower respondent fatigue and improve data quality. Caeyers, et. al (2010) found a positive correlation between the number of errors recorded during an interview and interview duration. More studies than not which examine the relationship between the method of data collection and interview duration show that CAPI interviews tend to be shorter. The idea being that selecting options from a list on a smart phone or tablet is generally quicker than hand writing answers on paper (CSO 2016; Zhang, et al 2012**)**. One study involving sample surveys in Kenya and Tanzania found that on average CAPI interviews were 16 minutes shorter than interviews conducted using PAPI. Notably this same study indicated that this time saving was not realized until after 3 days of data collection (Leisher 2014). Another study specifically designed to compare CAPI and PAPI using a Randomized Control Trial (RCT) showed that interviews conducted using CAPI were 10 percent shorter than PAPI (Caeyers, et. al 2010**)**. On the other hand,

a few studies have found longer interview durations by using CAPI or no statistically significant relationship at all (King, et. al 2013**)**.

### 2.3. Data quality

In terms of data quality, most if not all CAPI products allow survey designers to program validation conditions that detect erroneous data and display a warning message to the enumerator. Furthermore, routing errors are eliminated because skip patterns are programmed into the structure of the questionnaire and automatically enforced. Finally, since the data is immediately digitized during the interview, potential data entry errors during the transcription from the paper into a database are eliminated. Indeed, studies have found that data entry errors were eliminated using CAPI (Zhang, et. al., 2012, King, et. al 2013). Furthermore, the literature comparing results from the same questionnaire using both PAPI and CAPI found that the percentage of interviews containing erroneous data was much less for interviews conducted using CAPI (Caeyers, et. al 2010).

### 2.4 Enumerator opinion

The individuals affected the most by the choice of using CAPI or PAPI are the interviewers themselves. If all enumerators strongly prefer the traditional PAPI method, that may be enough justification to keep using it. The available literature suggests that enumerators prefer using electronic devices over paper questionnaires, for reasons such as less weight to carry around, reduced worry about correctly following skip patterns, easier organization and less risk of damaging completed surveys because of weather conditions. The only worry cited was the possibility of technical failure during an interview (Zhang, et al 2012; King, et. al 2013).

In summary, the literature indicates that CAPI shows promise as a cost-effective alternative to the traditional PAPI methods with the potential to improve data quality, reduce respondent through shorter interviews, and indeed when asked, enumerators seem to prefer CAPI tools. However, this evidence comes from on small sample surveys conducted by research institutes and, therefore, the conclusions are not necessarily applicable for NSOs that operate in a very context.

## 3. Methodology and data sources

The UBOS, NBS, and MALF assembled available data on costs, start and end time of interviews, and data quality for a number of surveys. A questionnaire was also distributed to a random sample of enumerators to assess their overall opinion of using CAPI to collect data in both countries.

### 3.1. Ugandan Bureau of Statistics

UBOS provided data for the first four waves of the National Panel Survey (NPS) from 2009 to 2014, a nationally representative multi-topic household survey. The first wave was performed using PAPI, while waves 2-4 were administered using a combination of Ultra-mobile PCs (UMPCs) and Lenovo tablets. The software used was Capture with Enhanced Survey Technology (CWEST). The number of questions in the four surveys varied between 1,090 and 1,152 and targeted information on education, health, labor, housing conditions, non-agricultural enterprises, vulnerable groups, agriculture (crops, livestock, and fisheries), water and sanitation. Each wave collected data from about 3,000 households.

Comparing the 4 waves of the NPS offers the opportunity to assess the cost and quality differences between CAPI and PAPI, as well as how the costs of adopting CAPI changes over time.

Furthermore, UBOS has a rich pool of enumerators with vast experience and knowledge of both PAPI and CAPI making them ideal respondents for comparing PAPI and CAPI. The start time, end time, and dates were provided for Waves 1 and 4 so that the duration of interviews could be compared.

### 3.2. National Bureau of Statistics (NBS) and the Ministry of Agriculture, Livestock and Fisheries (MALF) of Tanzania

NBS provided cost data for the 4th wave of the National Panel Survey and for the Tanzania Demographic and Health Survey (DHS). Both of these surveys were conducted using PAPI, so for comparison, MALF provided data for the 2015 Livestock Field Officer Survey (LOS) conducted entirely using CAPI. Data regarding the start time, end time, and date of each interview was available for the LOS survey. Many of the enumerators mobilized for the LOS had been employed by NBS meaning that they had experience conducting surveys on CAPI and PAPI. Accordingly, they were an ideal pool of respondents.

## 4. Analysis and Results

### 4.1. Cost comparison

Tables 1 and 2 below show a cost comparision per interview of each survey by cost category in 2005 Purchasing Power Parity (PPP[1]) dollars. Enumerator, and supervisor costs are the product of the number of enumerators and supervisors, daily remuneration, and number of days worked. Cost for data cleaning for surveys in Tanzania were computed the same way using the human resources for data cleaning. Data cleaning costs could not be estimated for Uganda.

The paper questionnaire costs include printing, transportation to/from field, and the product of the cost of yearly storage and required number of years. Even when a survey is implemented using CAPI, there are minor paper questionnaire costs because enumerators are given back-up questionnaires in case of equipment failure. The electronic equipment costs include the purchase price of the electronic devices used for data collection, accessories (e.g. extra batteries, anti-glare covers; etc.), data transfer, generators for recharging, and consulting fees if required. The costs of the electronic devices and accessories were divided by 5 as experience at UBOS showed that this type of equipment usually lasts for 5 rounds of data collection, after which it needs replacement.

It is notable that for the DHS and NPS-Wave 4 surveys conducted in Tanzania, double data entry was conducted: once in the field, and once in the office. The field data entry was conducted using tablets for the DHS and laptop computers for the NPS, which contributed to the equipments costs. It should also be noted that computers used for cleaning are not included in these figures. This is based on the assumption that an institution would likely use the same number of computers for CAPI and PAPI surveys.

In both countries, the cost per interview of surveys implemented with CAPI is lower than PAPI. Consistently, these savings can be attributed to lower paper questionnaire costs, and the elimination of data entry by CAPI. In Tanzania, the cost of data cleaning are also lower for the CAPI survey due to the higher data quality and the precoding of variables programmed into the questionnaire. In Uganda, the expenses of paper questionnaires decreased with subsequent years using CAPI. This is because UBOS gained confidence with the technology and printed fewer back-up paper questionnaires.

Furthermore, a minor contributing factor of the lower costs of CAPI is the fact that these values are given in PPPs. In Uganda, the enumerator and supervisor salaries were constant across

[1] Purchasing Price Parity were used because they provide a standard unit of measure to compare expenditures across multiple countries. More information can be found at www.worldbank.org.

all waves. So when the values were converted into PPPs, they appear lower because inflation is taken into account. In current local currency units, the enumerator and supervisor were the same across all four waves of the NPS.

**Table 1:** *Cost per interview in Tanzania in 2005 PPP values*

| **Description** | **NPS – Wave 4** | **DHS** | **LOS** |
|---|---|---|---|
| Year | 2014-2015 | 2015-16 | 2015 |
| Sample Size | 5,010 | 13,376 | 415 |
| Number of questions | 782 | 879 | 239 |
| Method of data collection | PAPI | PAPI | CAPI |
| Costs | | | |
| Enumerators salaries | 124.63 | 67.95 | 62.06 |
| Supervisor salaries | 32.40 | 14.84 | 32.85 |
| Data Entry | 24.09 | 14.10 | - |
| Cleaning costs | 10.80 | 2.72 | 0.21 |
| Paper questionnaire cost | 11.60 | 8.45 | 0.07 |
| Electronic equipment cost | 7.66 | 2.24 | 11.21 |
| **Cost per interview** | 211.18 | 110.29 | 106.40 |

Note: Values converted from Tanzanian Shillings to 2005 PPP values using the World Development Indicators (2016).

**Table 2:** *Cost per interview in Uganda in 2005 PPP values*

| **Description** | **Wave 1** | **Wave 2** | **Wave 3** | **Wave 4** |
|---|---|---|---|---|
| Year | 2009-2010 | 2010-2011 | 2012-2013 | 2013-2014 |
| Sample Size | 3000 | 3000 | 3000 | 3000 |
| Number of questions | 1090 | 1097 | 1152 | 1148 |
| Method of data collection | PAPI | CAPI | CAPI | CAPI |
| Costs | | | | |
| Enumerators salaries | 91.46 | 81.05 | 63.96 | 61.42 |
| Supervisor salaries | 45.27 | 40.12 | 31.66 | 30.40 |
| Data Entry | 28.38 | - | - | - |
| Cleaning costs | NA | NA | NA | NA |
| Paper questionnaire cost | 35.04 | 6.21 | 4.44 | 3.68 |
| Electronic equipment cost | - | 8.14 | 7.26 | 7.07 |
| **Cost per interview** | 200.16 | 135.52 | 107.33 | 102.56 |

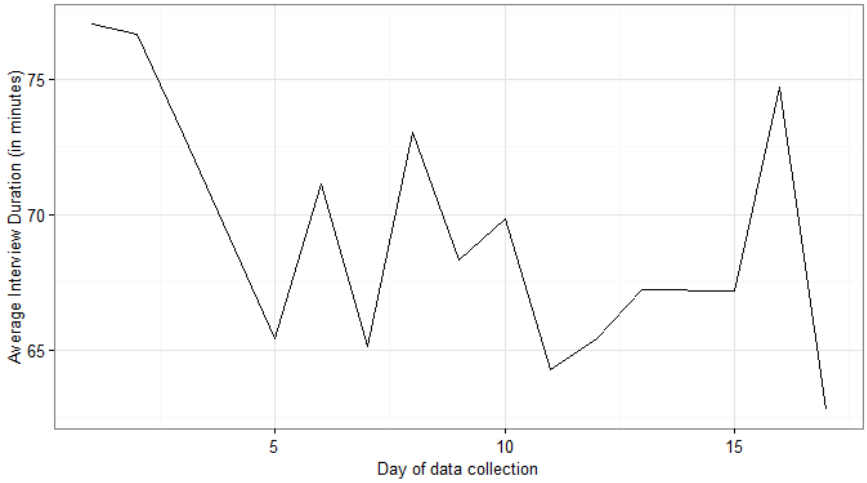
Note: Values converted from Ugandan Shillings to 2005 PPP values using the World Development Indicators (2016).

### 4.2. Interview Duration

As mentioned in Section 2, Leisher (2014) found that the interview duration of CAPI surveys decreased after the first 3 days of data collection. Figure 1 below reflects this same experience in the Tanzania LOS. The average interview duration by day drops from 77 minutes on

the first day of data collection to 66 minutes by day 5. Thereafter the average duration of interviews fluctuated, but never reached more than 75 minutes. Notably, the LOS involved a long and complex game as well as very challenging questions involving scenario building and behavioural projections. Thus, the data from this survey does not provide a good comparison with the other surveys from Tanzania, which are based on straightforward questionnaires.

**Figure 1:** *Average duration of interviews for the LOS survey in Tanzania*



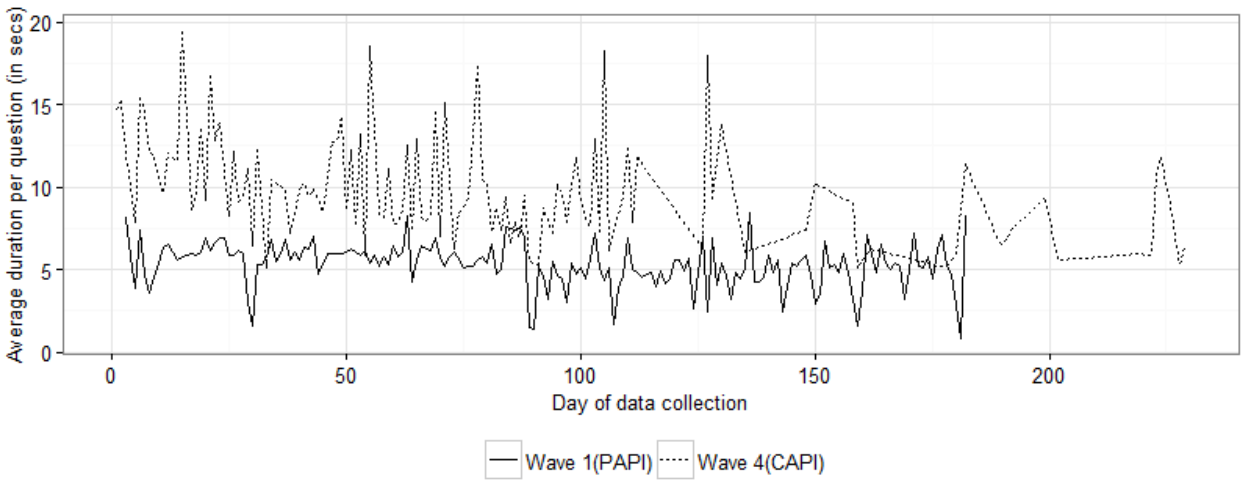

The start times and end times for Waves 1 and 4 of the NPS in Uganda were provided, and the duration of each interview was computed. Wave 4 had more questions than Wave 1, so the duration of each interview was divided by the number of questions. The duration of interviews across the two surveys were independent, ordinal, and did not follow a normal distribution. As a result, a Wilcoxon Sum Rank test was performed check if the difference was statistically signficant.

**Table 3:** *Comparison of interview durations across Waves 1 and 4 of the Uganda NPS*

| **Item** | **Wave 1** | **Wave 4** |
|---|---|---|
| Number of questions | 1090 | 1148 |
| Median duration per question (in seconds) | 5.83 | 7.67 |
| Mean duration per question (in seconds) ** | 5.57 | 8.48 |

Note: ** Indicates p-value < .05 as measured using the Wilcoxon Rank Sum test.

**Figure 2:** *Average per question in seconds for Waves 1 and 4 of the Uganda National Panel Survey*




Note: Missing values were imputed using linear interpolation.

Figure 2 shows the time series of average interview duration by day of data collection for both waves. Almost the entire series of Wave 4 conducted using CAPI lies above Wave 1 signaling that the CAPI interviews took longer. The Wilcoxon Sum Rank test indicates that the results are statistically significant confirming that interviews conducted with CAPI were longer in duration. This finding is at odds with previous literature that finds CAPI interviews are frequently shorter in duration. This can perhaps be explained by the fact that this survey is a panel, and in later waves, there is more information to cooberate from previous waves resulting in longer interviews. Furthermore, problems were reported with the tablets during Wave 4 including "black outs" and "freezing". These issues may have resulted in longer interview durations during the 4$^{th}$ Wave. Notably, these types of problems were not reported in other survey using CAPI.

### 4.3. Data Quality

As the PAPI and CAPI surveys were implemented in Tanzania by different institutions, no one was available to provide a comparision on the quality of data collected across the two methods. However, since the same staff at UBOS implemented all waves of the NPS, UBOS was in a excellent position to provide comparision.

According to senior statisticians inside UBOS, there was gradual improvement in the quality of data following the introduction of CAPI. First, most of the inconsistences previously found in data collected using PAPI were eliminated because they were addressed at the design stage in the programming of consistency checks. However some inconsistencies were still found, but were addressed through the regular updates to the application during data collection. This would not have been possible using PAPI.

Furthermore, CAPI facilitates the linking of the different modules due to prior programming and fixing of ID codes making data from different modules collected at the same household easier to merge. For Wave 4 for example, there was no need to re-enter names of household members from the household roster and it was easier to add new members of the households. In the case of PAPI, entire household rosters had to be rewritten for different modules which resulted in mistakes, and lower quality data.

In all cases, an analysis of the raw data – before being cleaned – would be needed to assess any significant difference in data quality between CAPI and PAPI. Unfortunately, this raw data was not available.

### 4.4. Enumerators' opinion

A questionnaire asking the enumerators sex, age, number of surveys implemented using electronic questionnares, number of surveys implemented using PAPI, and the rating of their experience using both tools was completed by 11 and 21 randomly selected enumerators in Tanzania and Uganda respectively.

**Figure 3:** *Enumerator experience rating of CAPI and PAPI surveys*

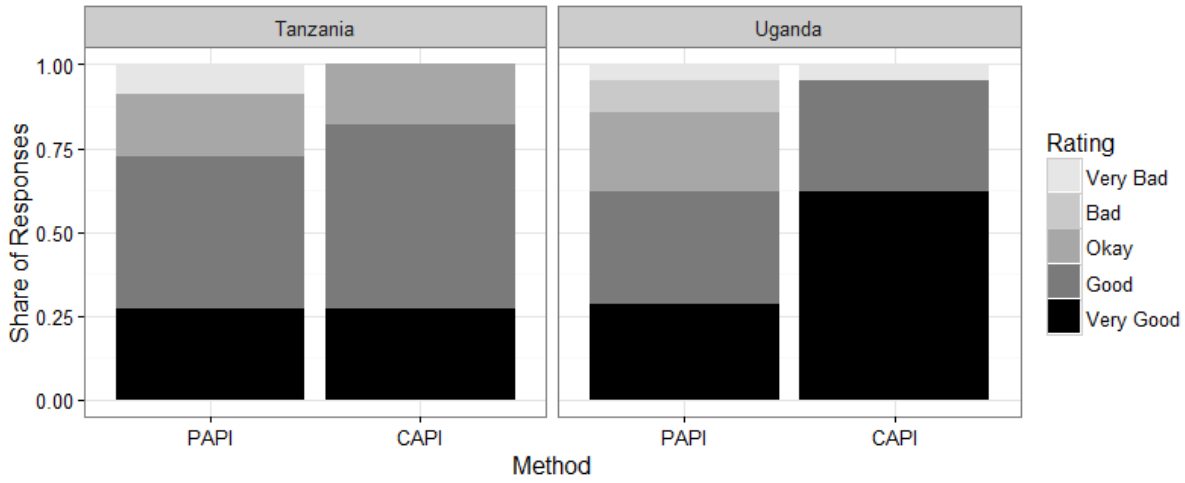



Figure 3 shows that more than 75 percent of enumerators rated their experience as "Good" or "Very Good" in both Tanzania and Uganda. Only one enumerator in Uganda described his/her experience as "Very Bad". Notably, this same respondent indicated that his/her experience with PAPI was also "Very Bad". The overwhelming positive experience with CAPI reveals an enumerator preference for electronic surveys.

## 4. Conclusions and Recommendations

As countries begin developing a strategy for collecting the data demanded by the SDG framework, additional pressure will be placed on NSSs with already signficant resource contraints. Accordingly, institutions must look for tools which reduce the cost of data collection without jeopardizing data quality. Experiences from small surveys conducted by research institutes indicate that CAPI could be a cost-effective alternative to PAPI due to reduced cost of printing paper questionnaires, and data cleaning costs resulting from higher quality data. Also, one study (Caeyers, et. al 2010) found that CAPI is more cost-effective for surveys with large sample sizes as the sample size increases, the fixed costs are offset by a reduction in variable costs. Some studies (CSO 2016; Zhang, et al 2012; Leisher 2014; Caeyers, et. al 2010**)**. also found a reduction in interview duration using CAPI reducing respondent burden, and that enumerators frequently prefer collecting data using electronic devices. Despite being informative, research institutes operate in a very different context than NSSs. As a result, the results form the currently available literature are of limited the applicability to NSSs.

This paper represents a first attempt to assess the advatanges and disadvantages of using CAPI vs PAPI by analyzing quantitative and qualitative information of cost, duration, data quality and enumerators' opinions from conducting large-scale surveys. Results indicate that the fixed costs of purchasing equipment for CAPI surveys is compensated by lower variable costs, and CAPI interviews are longer than PAPI interviews. The later result is highly questionnable and may be due to equipment failure as well as the use of a longitudinal survey. Also, statisticians in Uganda report an increase in data quality from switching to CAPI, and enumerators in both Uganda and Tanzania show a strong perference for surveys using CAPI.

This paper, though building on quantiative and qualitative information from only two countries, confirms that CAPI could represent a low-cost effective option to collect high quality data in countries with financial and human resource constraints. The advantages of CAPI over PAPI are also expected to become larger in the coming years, because of improvements in equipment, software and availability of internet services in rural areas especial for developing countries. Additional evidence is however needed to substatiante these findings. It is recommended that NSSs start systematically collecting and analysing paradata on their PAPI and CAPI based surveys, in order to better assess when to allocate their scarce resources for data collection through PAPI or CAPI.

## References


Caeyers, B., Chalmers N., De Weedrt J (2010) Improving consumption measurement and other survey data through CAPI: Evidence from a randomized experiment, *Journal of Development* Economics, 98, 13-33

Central Statistical Office (CSO). 2016. The Next Level "Advancements in ICT". St. Lucia. Accessed at: https://www.youtube.com/watch?v=chdKyeF_vuE.

Keita N., Carfagna E., Mu'Ammar G. (2010]). Issues and guidelines for the emerging use of GPS and PDAs in agricultural statistics in developing countries. *Conference proceedings from the 5th International Conference on Agricultural Statistics (ICAS V).* Accessed at: http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/ICAS5/PDF/ICASV_2.2_097_Paper_Keita.pdf

King J., Buolamwini J., Cromwell E., Panfel A., Teferi T., et al. (2013). A Novel Electronic Data Collection System for Large-Scale Surveys of Neglected. *Tropical Diseases*. PLoS ONE 8(9): e74570. doi:10.1371/journal.pone.0074570.

Liesher C. (2014) A Comparison of Tablet-Based and Paper-Based Survey Data Collection in Conservation Projects. *Social Sciences*. ISSN 2076-0760.

United Nations. (2016). Sustainable Development Goals: The Sustainable Development Agenda. Accessed at http://www.un.org/sustainabledevelopment/development-agenda/

World Bank. (2016). World Development Indicators. Accessed at: www.data.worldbank.org

Zhang S., Qiong W, et. al. 2012. *Smartphone Versus Pen and Paper Data Collection of Infant Feeding Practices in Rural China*. *Journal of Medical Internet Research*, 14(5): e119.