# Automating Internal Control at a Rural Coffee Cooperative

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***Abstract*—Internal control systems allow agricultural cooperatives to monitor the growing practices of their members, ensuring adherence to various standards for quality, and for meeting external certification requirements. In this paper, we present the motivation, design and evaluation of an automated mobile data collection, evaluation and reporting tool for internal control at a coffee cooperative. Our design goals were to improve the efficiency of this process, and to increase the accountability of various stakeholders. Based on a three-month pilot deployment, we have demonstrated a 30% reduction in inspection time and 71% reduction in evaluation time, compared to the earlier paper-based approach, which relied on several manual data collection and information processing steps. We also present the results of a qualitative evaluation of the system, including real field experiences and the perceived benefits and drawbacks of the automated system from the perspective of inspectors, farmers and other stakeholders.**

## I. Introduction

### A. Challenges Faced by Small Coffee Farmers

Small farmers in the developing world must compete in an increasingly competitive economic market. Due to their small size and limited capacity, they face significant challenges in doing so. Deficits in infrastructure and organizational capacity lead to increased transaction costs compared to larger producers. To compensate, small producers can avail a quality or marketing advantage by highlighting their specialized production techniques, geographic specialization and social impact. However, the lack of available transport, infrastructure, enforceable production standards and marketing channels limit this potential, causing small producers to continue to sell at commodity prices.

Coffee is a case in point. Coffee is now the second most traded commodity in the World, trailing only petroleum [1]. However, small coffee farmers, particularly in Central America, have not benefited from increased coffee trade and consumption. One reason is a corresponding increase in production. In the early 1990s, Vietnam started producing coffee. Coinciding with an increase in Brazilian production, the market was flooded, and worldwide coffee prices fell sharply. Growers in Central America, facing higher production costs (but growing better coffee), were decimated [2].

### B. Certification

In response, there have been several efforts to help small coffee farmers earn a living wage by capitalizing their quality advantage, sustainable growing practices and social impact. Many of these rely on some form of *certification*, where a third party ensures that socially and/or environmentally beneficial practices are being followed, and authorizes producers to sell coffee with a certified label to attract a price premium. This model assumes consumers will pay a premium for labeled products meeting various ethical and environmental standards. Some of the more prominent certifications for coffee include:

*1) Organic:* According to the International Federation of Organic Agriculture Movements (IFOAM), organic agriculture is an attempt to *sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings* [3]. Actual requirements for organic produce vary from country to country. One priority is reducing the use of chemical fertilizers and pesticides. Each importing country or region usually has its own standards, enforced by a certification agency responsible for performing farm inspections to ensure quality and prevent fraud by producers. As a result, most cooperatives only export organic coffee to a few regions and/or must be certified by multiple agencies.

*2) Shade-grown:* Shade-grown certification ensures that native shade trees are retained on coffee parcels, preventing sun damage, soil erosion and providing shelter to migratory birds that act as a natural insecticide [4]. Originally, all coffee was shade grown, until a sun-resistant hybrid was developed to increase the arable land available for coffee cultivation. Due to greater yield, this hybrid has replaced 17% to 69% of the total coffee cultivation (depending on the country) severely impacting the migratory bird population. Shade-grown certification was introduced in 1996 to address this problem.

*3) Fair Trade:* Fair Trade seeks to improve the status of marginalized producers by promoting consumer awareness, changes in trading practices and empowering producers to play a larger role in the marketing and sale of their coffee [5]. Certifying agencies monitor producer organizations' labor and environmental standards. Under Fair Trade regulations, Coffee farmers are guaranteed a minimum price of $1.26 per pound, or $0.05 above the current international market price,

whichever is higher. Fair Trade also encourages the establishment of direct relationships between producer organizations, roasters, and coffee importers.

### C. Cooperatives and Internal Control

Smallholders form cooperatives to reduce transaction costs, manage quality, increase market access, engage in policy discussions and access training and technical advice. Some cooperatives also provide social services to women and other marginalized groups. Cooperatives can help smallholders achieve certified status, which can be costly and time-consuming. There is the initial challenge of training farmers in the new standards and converting their growing practices and farms (which, in the case of organic, can take up to three years). Thereafter certifying agencies conduct annual (or, in some cases, semi-yearly) external inspections, including visits to a random sample of farms. If they observe any transgressions, the entire cooperative's certification (and price premium) could be at stake.

A cooperative's internal control department is responsible for inspecting each member's land and equipment in advance to ensure they meet the required standards, both for external certifications and the cooperative's internal quality standards. If problems are observed, they can be corrected, or for repeated violations, the member can be expelled. Internal inspections are carried out by trained *inspectors*, usually staff of the cooperative or advanced farmers, who inspect communities other than their own to avoid potential collusion.

For organic cultivation, inspectors must observe each member's processing equipment and land parcels to ensure organic growing practices are followed and to determine whether there is risk of contamination from neighboring fields. The results are delivered to *evaluators*, responsible for determining appropriate recommendations, reprimands or sanctions, often conveyed back to farmers through extension agents. Internal inspectors must ensure that problems have been addressed before the next inspection, or more serious action can be taken.

A cooperative's *internal control manager* aggregates inspection data to create a record for each farmer, and to prepare the required yearly reports for external certification agencies. Data can also be used for operational purposes, such as forecasting the next harvest. Internal control is a costly, labor-intensive process, consisting of several steps of data collection, aggregation, analysis, and use. In many cooperatives these processes are not standardized or automated, making them error-prone and requiring significant manual effort. An overview of the internal control process can be found in Figure 1.

### D. Our Partner: CEPCO

The Coffee Growers Association of Oaxaca (CEPCO) is the largest network of small coffee farmers in Mexico. Established in 1989 and based in Oaxaca City, CEPCO is organized into seven regional offices across the state of Oaxaca, each serving 3-10 smaller farmer organizations. CEPCO currently works with 33 such organizations, covering a total of 2760 producers, 90% of whom own less than 2 hectares of land.

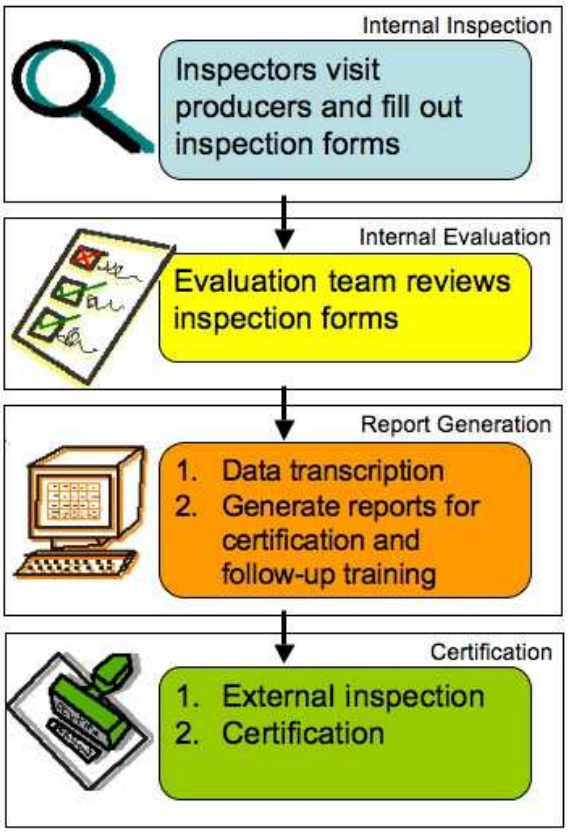


Fig. 1. Flow chart of the internal control process

In 1994, responding to the global price crisis and the elimination of subsidies from the government, CEPCO began promoting and marketing organic coffee, starting with a pilot group of 4 producer organizations. Currently, CEPCO's coffee is certified organic and fair trade. They employ 30 trained internal inspectors to perform yearly inspections, 17 technical extensionists to train other farmers in organic practices, both recruited from the ranks of coffee producers. CEPCO also has a 10-member team of evaluators. Except for the internal control manager, internal control staff are hired only when they are needed for the internal inspection period (usually lasting between June and November).

### E. Outline

In this paper, we present the design, implementation and evaluation of DigitalICS — an automated data collection, evaluation and reporting tool for internal control. Our design goals were to improve the efficiency of this process, and to increase the accountability of producers and inspectors. The rest of this paper is organized as follows: section 2 discusses the evolution of internal control systems at CEPCO. Section 3 describes some related (mostly commercial) systems for automating certification, monitoring, traceability and marketing of agricultural products. In section 4 we present the design of DigitalICS, and the benefits we hope to obtain. In section 5 we describe an evaluation of this system after a three-month

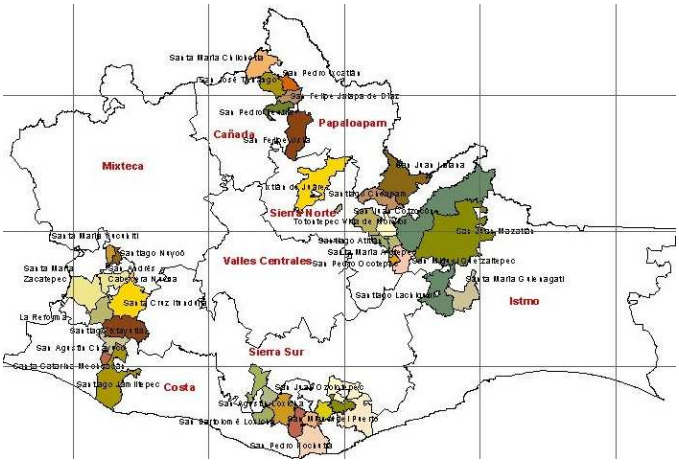


Fig. 2. The location of CEPCO's 33 producer organizations in Oaxaca

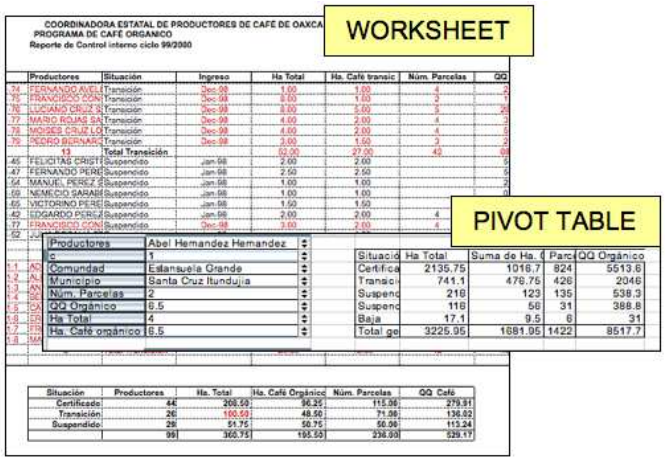


Fig. 3. CEPCO's Excel-based records in 2000

deployment, including the observed efficiency gains, and qualitative feedback from various stakeholders documenting their experiences and perceptions of the system. In section 6 we discuss these results. In section 7 we present opportunities for future extension and refinement of DigitalICS, and in Section 8 we conclude.

## II. Evolution of Internal Control at CEPCO

This section provides a historical perspective on the evolution of the information systems used for internal control at CEPCO.

### *A. 1994-1997: 5 Page Inspection Form + WordPerfect + DBase*

Initially, due to language and communication problems, it was very difficult for CEPCO to learn about organic standards through the relevant certifying agencies in countries where they were exporting coffee; including the USA (OCIA), Switzerland (Imo Control) and Germany (Naturland). Because external inspectors had to be flown in from US or Europe, inspection costs were also extremely high ($320 to $350 USD per inspector per day). CEPCO also had to pay the certification agencies a fee of between 0.5 and 1% of their total organic sales.

Transitioning to organic production required a significant investment in equipment and providing training and technical assistance to farmers. At first, CEPCO didn't even keep a persistent record of their members or their landholdings, required for providing traceability of organic produce. Their first 5-page long inspection form consisted of many open-ended questions, and required an exhaustive listing of the flora and fauna found on each parcel. The field inspections were done by the technical team at CEPCO, supplemented by a few leading producers. Evaluation was done in an ad hoc way, with each producer organization setting its own criteria. Some organizations assessed producers based on extraneous factors, including timely payment of fees and participation in meetings.

Some information, including each producer's name, estimated production, and total growing area, was entered by hand into a WordPerfect document at the CEPCO head office. Lists of organic producers were extracted and sent to certifying agencies in partial fulfillment of reporting requirements. Other reports were generated by hand. Crop estimates were stored separately in a DBase application, used by the sales department to estimate the coffee that would be available to sell.

### *B. 1997-2000: 2 Page Inspection Form + Excel + DBase*

In 1997, the internal control team decided to revise the process to make it more efficient and cost-effective. They reduced the inspection form to a 2-page questionnaire, with evaluation done in the field by the inspectors themselves. Inspection information was entered into Excel spreadsheets, one per organization, using pivot tables to query for information (see Figure 3) and to generate reports. Other reports continued to be generated by hand. The sales team continued to use their DBase application for forecasting purposes.

At this point a local agency, CERTIMEX, began conducting the external inspections, significantly reducing costs. Organic certifying agencies in the USA, Switzerland and Germany agreed to allow CERTIMEX to perform this function on their behalf.

### *C. 2000-2004: 3 Page Inspection + FileMaker*

In the early 2000s, there was a significant increase in the number of producer organizations growing organic (from 4 organizations in 1994 to 30 in 2002). Certifying agencies also began requiring separate departments for training and internal inspection to prevent conflicts of interest. To respond to these changes, CEPCO created a two-tiered internal control structure, with separate internal control and training departments at each of 7 regional offices, with a state-wide supervising team in Oaxaca City. Experienced inspectors were selected to a state-wide evaluation team.

CEPCO needed a database application that would allow them to better organize, store and utilize evaluation data. They decided to use FileMaker [6], because they couldn't afford to hire a programmer, had heard that Microsoft Access was too difficult to use by non-programmers, and that FileMaker had a less steep learning curve. The results of each evaluation and crop estimates for each producer were fed into this application. FileMaker allowed reports to be automatically generated — for certifying agencies, the sales team, and for including in funding proposals.

### *D. 2004-2007: 3 Page Carbon Copy Inspection + FileMaker*

Because of increased emigration from rural areas, frustration with labor-intensive organic practices and price competition with independent traders ("coyotes"), there was a decrease in the number of producers per organization. The evaluation committee also expelled many producers who were in violation of certification requirements. As a result, the internal inspection and training teams were once again centralized. Each organization is encouraged to provide their own internal inspectors to lower costs (inspectors from outside have to be paid by the local organization, but those from inside may do it as a service to their community, and incur reduced travel costs), but all internal inspectors report directly to CEPCO's main office. Evaluation and report generation continue to be done centrally.

Inspections are currently conducted using a three-page paper form with an attached carbon copy, with one copy going to CEPCO, and one to the local producer organization. Inspection forms focus on key "organic control points" — specific processes and uses of materials that are important to ensure compliance with certification standards. Evaluators still review these forms by hand, together with other supporting documents (maps, the producer's farm history, and previous recommendation reports), generating one hand-written report per organization. This report gets entered into the FileMaker database, which is used to generate reports for certifying agencies and other stakeholders.

### *E. Limitations of Previous Approaches*

In this section, we describe some limitations of CEPCO's earlier approaches to internal control, based on our observations, and discussions with farmers, inspectors, evaluators and the internal control manager.

*1) Inspection:*

- Inspection forms consist mostly of open-ended questions, creating a lack of standardization and introducing potential for subjective bias.
- Responses are hand-written, which is inefficient and difficult to do on steep coffee parcels. Inspectors must reach a stable place before they can fill out the form, causing them to forget details.
- Data is often lost, either due to dirt or rain on the paper inspection forms, or illegible handwriting.
- Inspectors sometimes do "office inspections", filling out reports while sitting at the local organization's office, instead of actually visiting the hard to reach coffee farms.

*2) Evaluation:*

- Evaluators review paper-based inspection reports by hand. When documents are presented out of order, it takes several hours to organize them before they can even begin the evaluation.
- Each producer has up to 6 documents that must be reviewed and cross-checked, again requiring significant manual effort.
- It is common to find discrepancies between producer documents. In such cases, evaluators need to consult the internal control manager or the regional office for clarification.
- Historical inspection data is difficult to access, both during inspection and evaluation.

*3) Report Generation:*

- Evaluation data is manually entered into the FileMaker database, introducing the potential for data entry errors.
- Inspection forms are never entered into the database. This makes it difficult to verify and cross-check information when discrepancies are found.
- New kinds of reports are difficult to generate, especially at the producer level, because inspection data is not captured. This limits the use of inspection information, and requires browsing through thousands of paper inspection forms to extract data.

## III. Related Work

e-cert is a commercial monitoring and certification system using a Tablet PC to perform field inspections [7]. A database application allows for the creation of inspection templates, scheduling of inspections and managing of inspection data. A group of UK food retailers developed the Social and Economic Development Exchange (Sedex), a web-based data management tool to track and audit labor standards along the wine, fruit and cut-flower supply chain [8]. ACTRES is another web-based system allowing flower growers to share information about their water and energy consumption, use of fertilizers and waste generation [9]. This is used to check compliance with certification requirements, and for growers to track their own use of natural resources. QualCheck captures quality assurance data during the processing, packaging, storage, distribution and serving of food and agricultural products [10]. Utzkapeh, an independent certifier of ethical and sustainable coffee producers, has developed a web-based system to track certified coffee through the supply chain from producers to consumers [11]. ApiTrack is a commercial product providing quality control and traceability for organic bee honey [12]. ApiTrack uses a proprietary Window CE hand held device to collect field data, indexed by barcodes printed on each apiary or beehive. Data is transferred to a web application via a wireless connection, allowing auditors to review the current status of individual beehives and/or apiaries.


Fig. 4. Flow diagram of the previous paper-based system (left) and DigitalICS (right) for the Internal Control process

DigitalICS is the only system intended for automating the internal control process. It is also the only system supporting data collection using a mobile phone, and utilizing commodity hardware and open source software, reducing the overhead of implementing the system. Finally, none of the systems listed above have been formally evaluated, either for efficiency, or based on stakeholder feedback, as we do for DigitalICS in this paper.

## IV. DigitalICS

In the rest of this paper, we describe the design and evaluation of DigitalICS (pronounced *digitalix*) — a fully automated inspection, evaluation and report generation system for internal control. The differences between DigitalICS and CEPCO's previous internal control system are summarized in Figure 4. Inspection data is captured using a mobile phone, including images documenting observed breaches of the certification requirements and the inspector's presence on the parcel; and audio recordings of feedback for the evaluation committee, the internal control manager, or the research team. Inspection data is automatically transferred to a web-based application, which is used for both evaluation and report generation. The mobile phone application, the web-based application and the resulting reports are all completely in Spanish.

### A. Inspection

DigitalICS provides a mobile phone application allowing internal inspectors to directly capture inspection data while in the field. It is written in Python for Nokia smartphones. The application prompts the inspector one survey question at a time, including both text and audio, compensating for the small screen and making it easier for inspectors to understand. The producer can also hear this prompt, sometimes removing the need for the inspector to restate the question. DigitalICS includes a small laminated booklet to guide the inspectors through the inspection process.

The inspectors can create new inspection forms or open saved ones through the application menu. Each form consists of ten sections that can be answered in any order. The application maintains a time-stamped log of data entry actions, to ensure that the inspector is taking sufficient time, including walking between parcels (a safeguard against "office inspections"). The survey questions are adapted from the previous inspection form. The form has been modified so that most questions have either numeric, Boolean or multiple-choice answers, standardizing responses, and limiting text entry. The inspector can attach an audio comment to any question, retaining the flexibility of the open-ended format. Inspectors can also capture images, for example to visually document breaches of the certification and quality requirements. This evidence reduces opportunities for producers to claim that they were treated unfairly.

Inspectors are required to capture a picture of the producer on the coffee parcel, and of the producer signing the inspection ledger, to prove they actually visited the farm. They are required to make an audio recording of the recommendations they make to the farmer, and the farmer's comments about how the community used the social premium they obtained according to Fair Trade regulations. DigitalICS provides a feedback mechanism for producers and inspectors to send an audio message back to CEPCO (and to us), about the new system, or anything related to their relationship with CEPCO. Pictures, audio recordings and entered data can be reviewed by browsing the tabs that appear at the top of the screen (see Figure 5).

### B. Data Transfer

Captured data is saved on the phone's external memory card. After all the inspections have been completed, inspectors go back to the CEPCO head office and transfer data by removing the memory card and inserting it into a USB card reader connected to a PC. We decided to adopt a *sneakernet* solution because of the limited wireless coverage and services in the region, and to save on connectivity costs. It is not essential that inspection data be transferred to the head office immediately, and inspectors must return to the office to discuss their observations with the internal control manager anyway.

### C. Evaluation

After the data is transferred to the PC, we run a script that processes it and posts the result as a blog entry (see


Fig. 5. Mobile Application Screenshots: Top left: Main menu; Top right: Section view; Bottom left: Input view; Bottom right: Reviewing multimedia

Figure 6). We use Wordpress as our back-end software, and Postie (a Wordpress plugin) to automatically format images and text [13]. Each post is automatically tagged with the producer's unique code, providing easy access to historical data. While Wordpress does not provide the same functionality as a custom database application, this approach has been sufficient for this application, and has required very little unnecessary development effort. Screenshots can be seen in Figure 7.

We designed another Wordpress plugin for evaluation and report generation. Breaches of certification standards are automatically classified according to rules specified by the management. Evaluators can log in, review inspection data (including pictures and audio), and enter their recommendations. Evaluation reports can be generated interactively by choosing data and recommendations from the inspection forms. The internal control manager can also provide recommendations and correct mistakes in the inspection forms. We have implemented a non-editable view for external certification agencies that is a filtered subset of inspection data and evaluation reports. We hope this can eventually reduce the number of visits needed for external inspection.

### *D. Report Generation*

Reports are automatically generated from the internal inspection data and evaluation results. These reports are currently used for internal control, making supply predictions, preparing funding proposals and for third-party certifying


Fig. 6. Screenshot of uploaded inspection data, formatted as a blog entry.

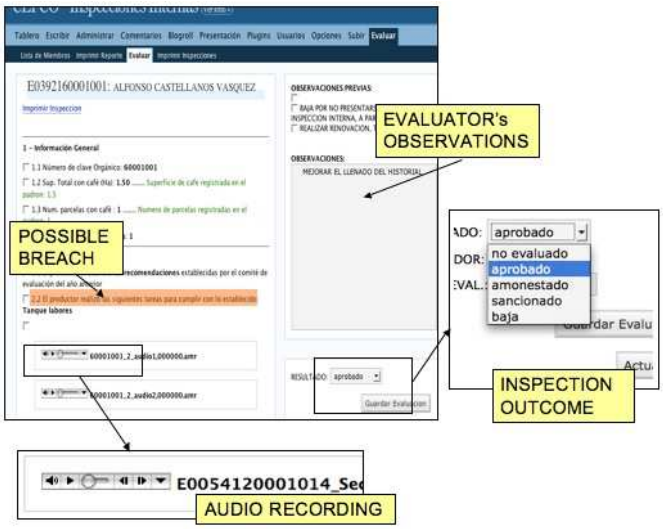


Fig. 7. Screenshot of application screens used for evaluation.

agencies. CEPCO uses the system to generate a single inspection report per producer, which is kept for internal records. Data is also exported to the legacy FileMaker application, used for generating reports that are not provided in the Wordpress application.

## V. Evaluation

DigitalICS underwent a successful user trial in Guatemala in 2006 [14], and a small pilot test with CEPCO in 2007. Starting in June 2008, DigitalICS has been used to inspect half of CEPCO's producers, while the other half are using the previous system. Eight Nokia 6600 phones were issued to CEPCO for conducting the inspections. Six inspectors were trained in the field by the first author over a two-day period,

with stronger users were paired up with weaker ones to help them learn the system. The Wordpress application for evaluation and reporting is hosted on the Internet, allowing for remote update of software and review of data by the research team. As of September, 516 producers have been inspected using DigitalICS. The rest will be completed by November.

In this section, we present an evaluation of this deployment, in terms of the efficiency gains that have been observed, and qualitative feedback gathered from inspectors, producers, evaluators and the internal control manager through various mechanisms.

### A. Efficiency and Cost- Benefit

*1) Methodology:* In order to study the differences in efficiency between the paper-based system and DigitalICS, we collected CEPCO's accounting data for 2007 and 2008, for the 7 producer organizations that have been inspected using DigitalICS so far this year. CEPCO keeps records of the number of days it takes to inspect an organization, the number of hours it takes to evaluate it, and the number of producers inspected for each organization. Inspectors are paid by the organization, while evaluators are paid by CEPCO on an hourly basis.

*2) Results:* The results can be found in Table I. On average, it was 30% faster to perform one inspection and 71% faster to perform one evaluation using DigitalICS. When averaged across all seven organizations, the reduction in evaluation time was a statistically significant difference ($p < 0.01$). Because DigitalICS greatly reduces the paperwork for evaluation, including organizing and reviewing the inspection forms, and manually copying information to the evaluation reports, this drastic time improvement is expected. In DigitalICS, all the data needed for evaluation is consolidated into one screen (see Figure 7), from which evaluation reports are automatically generated. The reduction in inspection time is not as significant, as it is dominated by the time spent walking from parcel to parcel. Considering this, even a 30% improvement is impressive.

Based on the wages earned by inspectors, evaluators and the internal control manager; and the reduction in inspection time, evaluation time, data entry, and printing costs for inspection forms; we estimate that a full deployment of DigitalICS would save CEPCO approximately 42,000 pesos ($4000) per year, or 29% of the total cost of internal inspection. Assuming a $25,000 dollar initial investment in software development, purchase of 30 mobile devices at $150 per device, and operating costs (including web hosting, technical support and hardware maintenance) totalling $600 a year [1], this generates a 12% annual return, with the hardware cost almost recouped within the first year. Future deployments would have much lower development costs (considering the DigitalICS software is open source), having to recoup only the cost of the hardware, training (which for CEPCO is the same as for the paper-based system) and yearly operating costs.

[1]All hardware, software and operating expenses are currently being borne by the research team.

TABLE I
ESTIMATED EVALUATION AND INSPECTION TIMES FOR SEVEN PRODUCER ORGANIZATIONS, USING THE PAPER-BASED SYSTEM IN 2007 AND DIGITALICS IN 2008

| Description | 2007 / PAPER | 2008 / DIGITALICS |
|---|---|---|
| Producers | 548 | 516 |
| Inspection days | 88 | 58 |
| Inspection days per producer | 0.16 | 0.11 |
| Evaluation hours | 48 | 13 |
| Evaluation hours per producer | 0.09 | 0.03 |

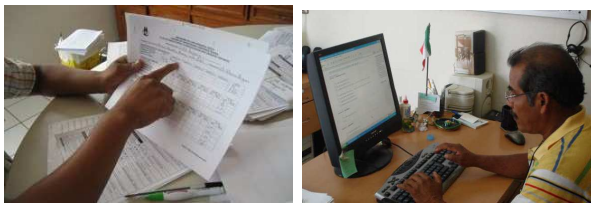

Fig. 8. Conducting an evaluation with the paper-based system (left) and with DigitalICS (right)

### B. Stakeholder Perceptions

*1) Methodology:* CEPCO regularly convenes assemblies in Oaxaca City to discuss issues of common interest, including monthly meetings with one representative per producer organization, as well as bi-annual meetings of all the producers. The focus of the August 2008 assembly was "The Status of Internal Control", including a presentation from CERTIMEX and other deliberations between members, inspectors, evaluators, and management.

During this meeting we conducted the following two exercises to understand the perceived benefits and drawbacks of DigitalICS compared to the earlier paper-based approach, from the perspective of farmers, inspectors, evaluators and management. We also wanted to learn about any technical or operational issues faced by users of the system, and their real experiences using it in the field. Both of the exercises below were conducted in Spanish. Translated quotes are provided by the first author, a native Spanish speaker.

- *Group Discussions* — The participants at the assembly were divided into six stakeholder groups: four inspectors who had used DigitalICS, four producers who had been inspected using DigitalICS, two groups of producers who had **not** been inspected using DigitalICS (five and four, split because of size), four Inspectors who had **not** inspected with DigitalICS, and one group of Evaluators (one of whom had used the system, and two who had not). Each group was asked to discuss the benefits and drawbacks of DigitalICS compared to the paper-based system. They wrote their conclusions on a big piece of paper, and chose a representative to present them to the rest of the assembly. During the presentation, the floor was open to questions, comments and suggestions from the other stakeholder groups.

- *Questionnaire* — Four internal inspectors who were present at the assembly and had used DigitalICS completed a questionnaire covering their perceptions of the relative advantages and disadvantages of both systems, and a summary of their experiences using DigitalICS. This allowed us to learn about specific operational issues faced while using DigitalICS in the field.

*2) Results:* This section summarizes the observations from the group discussions and the questionnaires. In general, it was difficult to keep the discussions focused on the changes introduced by DigitalICS. Participants often mentioned other issues, including their frustration with the low price of coffee, the expense of internal control and certification, communities not being notified or prepared for the internal inspection, and other operational issues. Because the general assembly included discussions about the price of coffee, and subsidizing each organization's external inspection costs, these digressions were not surprising. While these are clearly important topics, they are also not immediately related to DigitalICS, and are not covered below. The observations are separated into five general categories: Inspection, Technical Issues during Inspection, Evaluation, Impact on Accountability, and General Opinions.

**Inspection**

- Inspectors that had used DigitalICS felt that the phone was lighter and easier to carry then a stack of paper forms.
- Some inspectors mentioned that "the phone speaks for them", making formulating questions easier and faster.
- Some producers felt that using DigitalICS, the questions were being asked *too fast*. According to one producer,

  > *There wasn't a lot of time for answering. Sometimes the phone speaks to you and then it turns off [actually, the screen saver had come on], so it didn't give us time to answer.*

- Evaluators, producers and inspectors who were familiar with DigitalICS felt that inspection data was more secure from rain, dirt and/or illegible handwriting. One producer said:

  > *We feel more secure because we feel the information is stored more securely (on the mobile phone)...*

- One of the inspectors said that it was easier to review data using the paper-based system because "you could read the inspection report point by point". The small phone screen made such review more difficult.
- Some inspectors did not like that inspection data could not be reviewed at the regional office. Earlier, some corrections could be done there, before the inspection forms reached the CEPCO head office. Now evaluators and the internal control manager had to call the regional office for clarifications.
- Inspectors who used DigitalICS liked that it made it easier to directly capture data while standing in the coffee parcel and while reviewing equipment, without requiring a stable place to sit and write.
- All inspectors found it difficult to record open-ended comments using DigitalICS, and felt that important information was left out of the standard questions and responses. Very few inspectors captured supplemental images and audio recordings. One of the inspectors even said he wanted to learn how to "write" using the phone.
- One inspector felt that DigitalICS was more environmentally-friendly because it could save the paper used for printing inspection forms (up to 9,000 sheets per year).
- Several inspectors were worried about being held responsible for phone damage or loss. One said the phone accidentally fell into a pool of rainwater, and he was very concerned that it would stop working. All the inspectors urged us to get rain-proof covers for the cellphones. One of them half-jokingly said:

  > *It would be great to build a mini phone tent to protect the mobile phone.*


Fig. 9. Increasing accountability: The top picture shows an inspector taking a picture of a producer in her parcel. The bottom picture shows the inspector documenting inorganic trash (marked with a red circle).

*Technical Issues during Inspection*

- All the inspectors mentioned that the phone battery discharged too quickly — usually after approximately 4-6 hours of use. Inspectors were concerned about making the arduous trek to a village without electricity, only to find they couldn't do the inspection. Most carried an extra phone or battery as a precaution.
- Reviewing the captured multimedia often made the application slow down or freeze, likely due to memory and processor limitations of the phones we were using.

**Evaluation**

- Evaluators were especially happy with the reduced paperwork, improved efficiency and time-savings provided by the automated web-based application. Evaluators were especially frustrated by having to organize and sort through paper inspection reports and other documents in the earlier system.
- Evaluators felt that the earlier system led to more mistakes, both in inspection and in evaluation, due to the manual paper work required.

**Impact on Accountability**

- Producers that were inspected using DigitalICS liked that inspectors took pictures of them and their parcels. Having pictures taken made them feel more responsible and respected for their work.
- Evaluators mentioned that requiring images and audio recordings of producers increased the accountability of the inspectors (to visit the farms) and of the producers (to follow organic practices). One of them said

  *Using pictures and audio makes producers more identifiable. It is also easier to determine when the internal inspector is cheating by not visiting the coffee parcels.*
- Producers and inspectors who had experienced DigitalICS also felt that it increased accountability. However, those that hadn't used DigitalICS thought there could still be opportunities for cheating. One of them mentioned that an inspector could gather several producers and take pictures of all of them on the same parcel.
- Another concern voiced by producers and inspectors was that DigitalICS makes it too easy to edit information on the phone, leading to opportunities for cheating. The carbon-copied paper form was thought to be much more difficult to modify.
- One of the producers said that if you were familiar with technology, it would be easy to modify the information on the phone.

**General Opinions**

- Producers, evaluators and inspectors that had used DigitalICS all said the system was more efficient then the earlier version.
- Most of the people who had used DigitalICS were ready to implement it right away across all of CEPCO. They encouraged training all the inspectors immediately to make sure that the system would continue to be used, even in the case of staff turnover.
- Others who hadn't used the system wanted to do a more thorough evaluation to make a more informed decision based on an estimate of the relative cost and benefit. It is possible that some of these inspectors has seen others use the system, and simply wanted their own chance to "play".

### C. Qualitative Feedback

*1) Methodology:* We included a feedback button in the mobile application to allow inspectors and producers to leave audio recordings with their questions, comments and suggestions about the system, including an optional image, which would be uploaded to the web server along with the inspection data, for review by CEPCO and the research team. The goal was to overcome users' hesitation to comment on the system, by allowing them to do so while they were in *context*, using the system in the field, and in a way that was non-confrontational, without the research team or another authority figure present. We also hoped to generate more observational usage data than was possible during our own limited visits to the field. Initially this was optional; inspectors could only access the feedback function through the menu. Later we made it mandatory, asking both the inspector and the producer for feedback at the end of every inspection.

*2) Results:* In total, there were twenty pictures and 59 audio recordings captured during the 516 inspections. Most of the pictures were irrelevant, or taken without context. Twelve of the recordings were empty or stated they had no comment. In Table II, we provide a categorization of the most common kinds of feedback (some comments covered more than one category). A few of the more interesting comments are listed below.

- Twelve producers said that the new system would make them more responsible. One said

  *Now we have to do the required agricultural activities because earlier sometimes we didn't do them but now you can see what is and isn't being done ... and that's OK because we are not playing games, we are doing a job to increase production and produce better coffee.*

  Another, referring specifically to the pictorial evidence, said

  *It's good because there's no deceit. Each producer needs to be responsible for [doing] their own job.*
- One of the producers described exactly how he thought the system worked:

  *This is better so that you can store them [the inspection reports] and then when you get there [main office] you can store the documents in the computer... you can empty the phone onto the computer*
- One producer liked that DigitalICS allowed the outside world to see who he was and what he did for a living:

TABLE II
CATEGORIZATION OF USER FEEDBACK OBTAINED THROUGH THE MOBILE APPLICATION (P STANDS FOR FEEDBACK FROM THE PRODUCER, I FOR THE INSPECTOR)

| category | count | who | description |
|---|---|---|---|
| accountability | 12 | P | creates more responsibility for everyone to do their work |
| praise | 11 | P/I | the system is good/excellent; other forms of generic praise |
| design | 10 | I | design issues / bugs |
| efficiency | 6 | P/I | this system is more efficient |
| empty | 6 | PI | empty message |
| no comment | 6 | P/I | no comment |
| price | 5 | P | we need a better price for coffee |
| suggestion | 3 | I | inspector recorded recommendations for producers (which should have been recorded in an earlier question) |
| agriculture | 2 | P | discussing growing practices |
| cooperative | 2 | P | talking about CEPCO |

> *Because in this way it is more transparent to see that we are indeed coffee producers*

### D. Limitations of the Study

In this section, we list some potential limitations of this study:

- It should be noted that CEPCO's internal control systems and procedures were already quite advanced. Other cooperatives may benefit even more from the automation and standardization provided by DigitalICS; or if the basic organizational structures are not in place, may not be ready for it at all.
- If a cooperative's paper-based processes are already fully optimized, the advantage obtained by introducing a digital system could be more limited in terms of direct efficiency improvements. However, they could still benefit from improved access to and use of inspection data.
- The results of this evaluation may be different for other geographies, for example in South Asia or Africa. For example, labor costs may be much lower, reducing the financial benefit obtained by efficiency gains. Transportation may also be much more difficult, making it more cost-effective to remotely transmit inspection data.
- Our data is based on a sample of one cooperative's internal control for one growing season. A more rigorous study would involve several cooperatives, perhaps over several inspection cycles.
- As mentioned, using the previous system it was common for inspectors to do "office inspections", instead of actually visiting the coffee farms. While we've made some improvements, it is not possible to rule out that some DigitalICS inspections were not performed at the grower's coffee parcel. Similarly, we also can't know if this is true for 2007.
- The format of the inspection form was changed, from open-ended questions to ones that could more easily be answered using a mobile device. This advantage could also carry over into the evaluation, by producing more standardized reports with well-defined rules for providing recommendations. We cannot be sure what percentage of the efficiency gains are due to this change in format and increase in standardization, versus the automation itself.
- While the system does seem to save money on a yearly basis, it still requires regular technical support and maintenance to be sustainable. This requires a local service provider willing to provide this service for a reasonable fee. The availability of open source software like DigitalICS greatly reduces the barrier to entry for other cooperatives considering this approach. However, since we paid for the entire implementation and deployment with CEPCO, it is yet to be seen whether a cooperative would adopt such a system on their own.
- We have not explored any of the benefits provided by maintaining improved records of producers and their inspections. It is anticipated that these would only emerge through a longer study.

## VI. DISCUSSION

Through this evaluation, we were able to demonstrate the potential for improving the efficiency and accountability of CEPCO's internal control processes. The efficiency gains we observed were largely found in the reduction of evaluation time, and of other overheads, such as printing costs for forms. Reduction in inspection time was not as high, as that is dominated by the actual physical act of visiting parcels, reviewing equipment and walking between parcels. Considering this, even a 30% improvement is impressive.

During our qualitative feedback sessions, both producers and inspectors perceived an increase in their accountability to the internal control process. However, both groups recognized that the current solution was not tamper-proof. We also uncovered some interesting observations from the real-world deployment, including user and stakeholder perceptions of the system, and technical issues for keeping it running. Throughout this process, we obtained a lot of useful feedback about the interface design and the overall application functionality. We plan to integrate these suggestions in the next iteration of the software. In the following section, we discuss some other areas for future work.

## VII. FUTURE WORK

In this section we list some areas in which we hope to extend or refine the DigitalICS system.

- The current system still cannot ensure that inspectors actually visit the coffee farms. We want to explore other forms of accountability guarantees, including using GPS and other non-technical mechanisms, and their relative performance in terms of ensuring compliance.
- We would like to find better ways to present inspection data on the phone, including historical data, to allow inspectors to refer to it while they are in the field.
- We need to investigate alternate ways of keeping phones charged, including using solar chargers and other recharg-

ing equipment, as well as ways of reducing power consumption in our application.

- Find ways to encourage inspectors and producers to capture more images and audio recordings, both as part of the inspection, and as feedback for CEPCO and the research team.
- Explore using DigitalICS for certifying agencies to conduct external inspections.
- Use the data generated by DigitalICS to improve direct marketing of coffee — include making inspection data, images and audio recordings directly available on the web for consumers, and providing mechanisms to support two-way communications between producers and consumers.
- Find ways for DigitalICS to become a more general tool for cooperatives, and for any organization involved in procurement, extension, input supply, and in maintaining relationships with farmers or their rural constituents.
- We have already received requests for implementing DigitalICS with several other organizations in Central America, Africa and South Asia. We need to build a sustainable model to distribute and implement this software, working with local organizations to provide training, technical support and maintenance in these regions.

## VIII. Conclusions

In this paper we have presented the motivation, design and evaluation of DigitalICS — an automated mobile data collection, evaluation and reporting tool for internal control at a coffee cooperative. After a three-month deployment, we have demonstrated an average 30% reduction in inspection time and 71% reduction in evaluation time, when compared to the earlier paper-based approach, which relied on several manual data collection and processing steps. We have also described the real field experiences and perceived benefits and drawbacks of the system from the perspective of users, farmers and other stakeholders. Based on these positive results, CEPCO is planning to completely transition to DigitalICS in 2009, using it for all of their producers and the entire internal control process.

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