AGRICULTURE AND ENVIRONMENTAL SERVICES TECHNICAL ASSISTANCE PAPER 01

ICT FOR DATA COLLECTION AND MONITORING & EVALUATION

Opportunities and Guidance on Mobile Applications for Forest and Agricultural Sectors

THE WORLD BANK

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PROFOR

AES
Agriculture and Environmental Services

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GLOSSARY

Custom	The solution relies on special analysis software developed or customized specifically for a given client.
Custom installation	The software or system is installed to client's premises and is expected to be serviced for maintenance physically at the client's site or remotely (see also *Remote Management*).
Custom SW	The software is developed or tailored specifically for customer needs and is usually made available for that particular client only. Intellectual Property Rights (IPR) to the software in full or in part may be with the service provider (developer) or with the client, depending on the explicit agreement between the two. Background IPR (anything existing or developed prior to the client project) remains typically with the developer or service provider.
eCognition	Image analysis software for geospatial applications.
External GPS	Mobile device or application relies on external device that is able to record geographical coordinates and transfer these data to a mobile device via wired or wireless data transfer mechanisms.
GIS	The Geographical Information System provides the ability to perform spatial analysis on the data set. This usually requires geographical location information being part of the data set at some level (coordinates, street addresses, etc.).
GPS	Support of Global Positioning System in mobile device allows mobile application to obtain geographical location information directly from within the mobile device.
Hosted	The software or system is installed and run usually at the service provider's premises, but the client has access to the system via regular data communications networks such as Internet or telephony networks. The service provider is responsible for maintenance.
ICT	Information and communication technology
In-house support	Client organization's own personnel provide support. This is usually the case when open-source systems are used.
iOS	Formerly the iPhone Operating System
IT	Information technology
License fee	The software or system is made available for use against a fee (a copy of the system is sold to the customer). Client modification of the software is usually not allowed. Support and maintenance are usually not included in the license fee (inclusion or exclusion of these should be clearly stated in the licensing terms or licensing agreement).
M&E	Monitoring and evaluation
Offline use	Capability to collect data when a mobile device has no active mobile data connectivity (for example, in remote areas).

Online use	Capability to collect data directly into a central database by communicating the inputted data immediately over an active data connection (usually a cellular data or Wi-Fi network). This usually involves a data connection being available to collect data.
Open source	Software licensing model in which the software is offered for use for free and can usually be modified at will; depending on the specific terms of the open-source license, the modifications may need to be offered for free to all other users of the software.
Outsourced support	Support is provided by a specialist third-party company or organization that is not providing the software or a service.
PDA	Personal digital assistant
Remote management	The software or system is usually installed at the client's premises but the service provider can perform maintenance activities remotely by accessing the system via computer data network such as the Internet.
SaaS/cloud	Software as a Service concept usually relies on the software or system being installed in third-party computer hosting facilities, with both the client and the service provider accessing the system remotely. The system is usually maintained and serviced by the service provider.
Service provider	Support is given by the service provider that is the source of the software or service.
Signature	Capability to input graphical signature digitally by writing with a finger or a stylus, usually on a mobile device that has a touch screen.
SMS	Data collection relies on use of mobile device's SMS capability, either to transmit human-composed SMS messages (that may or may not be specifically encoded or formatted according to project specifications) or as an underlying data transmission platform for a mobile application.
SPSS	A statistical analysis software suite developed and marketed by IBM.
Subscriptions	The software or system is available for use only when subscription is active. When the subscription ends, the right to use the system usually ends.
Two-way sync	Data can be uploaded from device to server and also downloaded from server to device.

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PREFACE

This study was developed to assist development practitioners in assessment and selection of information and communication technology (ICT) applications for monitoring and evaluation in rural projects, specifically in agriculture and forestry, with an emphasis on mobile technology for data collection. Particularly in highly decentralized projects, data collection can be challenging, and the large number of options and specific project needs makes selecting technology a challenge. This report was developed in response to an identified need for development practitioners to be able to stay current with changing technology and identify appropriate avenues for assessing and selecting technology to support monitoring and evaluation (M&E) as well as project outcomes.

The report proposes guidance in selecting and applying technology for data collection and monitoring and evaluation through the lens of agriculture and forestry projects. It is designed to be a deep-dive, operational piece that tackles how governments and development practitioners can use ICT to enhance their data collection and M&E efforts in rural development projects and programs.

Chapter 1: OVERVIEW

Tracking progress in sustainable agriculture and forest management is challenging: distances are long, populations are sparse, interventions range from policies to crop and livestock practices, and the voice of the farmer is critical for success. Recent approaches focusing on climate impacts and land use pressures (climate-smart agriculture and landscape approach) add to the complexity and require efficient data collection and analysis methods. Heightened unpredictability and changes in weather patterns have affected the productivity and risks associated with agriculture and forestry activities and therefore the lives of the communities who depend on them. The urgency to obtain reliable data and their analysis and distribution to different stakeholders have increased substantially—given the global uncertainty around food production, commodity trade, food prices, and the effects and speed of climate change. Furthermore, sustainable agriculture and natural resource management solutions are becoming interlinked and more knowledge-intensive, requiring reliable data for decision making.

Alongside increasing climate change concerns is a promising trend: fast-moving, cost-effective, widespread information and communication technologies (ICT)—especially mobile phones. Their affordability and pervasiveness has made them viable tools for data collection. With near real-time feedback from the field, technology is facilitating the ability to oversee operations across dispersed geographic locations, obtain complete data sets at a faster and more efficient pace, and evaluate results more often and with a tighter and clearer feedback loop to practitioners implementing programs. The systemization of ICT in the monitoring and evaluation (M&E) process also enables accountability—from field staff to regional and central governments and development partners. It also supports evidence-based decision making and the effective allocation of resources in order to maximize social impact.

To support the growing interest among practitioners in using ICT in agriculture and forestry sectors, the World Bank published two reports on information technology (IT) in rural landscapes in 2011. The ***ICT in Agriculture e-Sourcebook***[1] explores how digital tools—mobile devices, applications, software, and geographic information systems (GIS), among others—can be used in 14 different agriculture subtopics ranging from productivity to risk management. The ***2012 Information and Communication for Development*** report dives into mobile applications across different sectors, including agriculture, with a focus on value chains.[2] In addition, the ***eTransform Africa*** report provides data and insights for the transformational power of ICTs with sectoral examples, including agriculture.[3] Within the forest sector, ***Forest Governance 2.0: A Primer on ICTs and Governance***[4] examines the role of technologies ranging from radio and mobile phones to hi-tech satellite imagery in increasing public participation, enhancing economic efficiency, and improving law enforcement. All of these reports aim to highlight the opportunities found within the ICT innovation space for agriculture and forests.

Since the publication of these reports, significant progress has been made on multiple fronts. Improvements in infrastructure have made the mobile phone the most common and most adaptable tool used worldwide. The leapfrog effects of ICT have increased access to quality information, eased knowledge sharing among practitioners and resource-constrained governments, and created opportunities to improve accountability. The expansion of ICT has also made

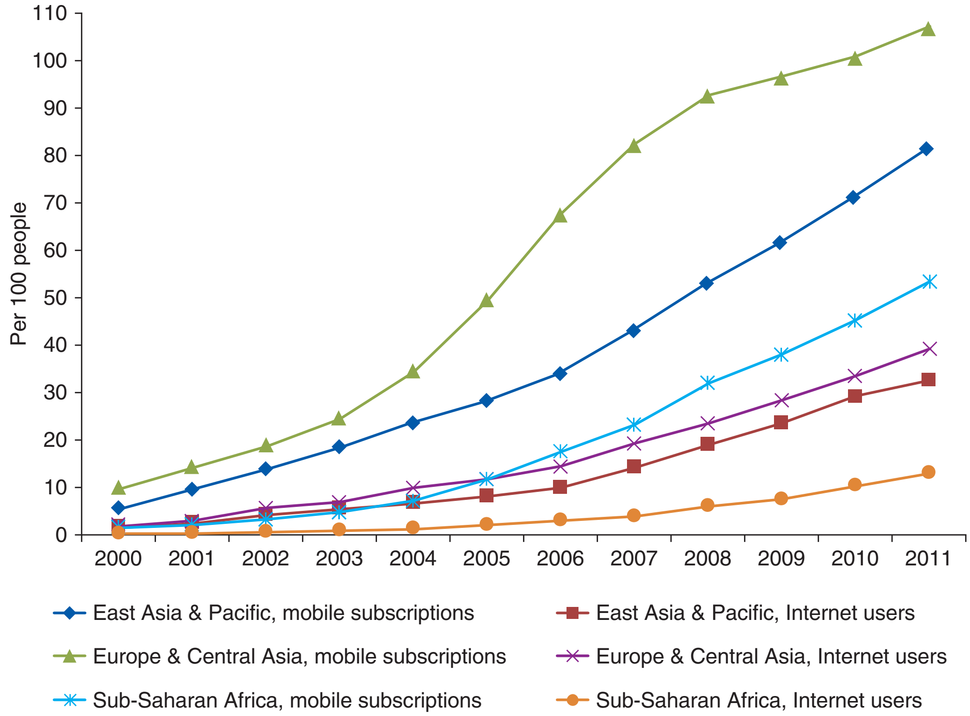
1 www.ictinagriculture.org.

2 http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/IC4D-2012-Report.pdf.

3 http://www.infodev.org/infodev-files/resource/InfodevDocuments_1162.pdf.

4 http://www.profor.info/sites/profor.info/files/docs/Forest%20Governance_web.pdf.

FIGURE 1.1: Mobile Phone and Internet Penetration in Selected Regions (2000–11, per 100 persons)



Source: World Bank 2013 and World Development Indicators 2013.
Note: Data includes only developing countries in the regions.

the work of development practitioners easier and more accurate. In some regions there are already more mobile phone subscriptions than people, and even Internet access has become more common. (See figure 1.1.)

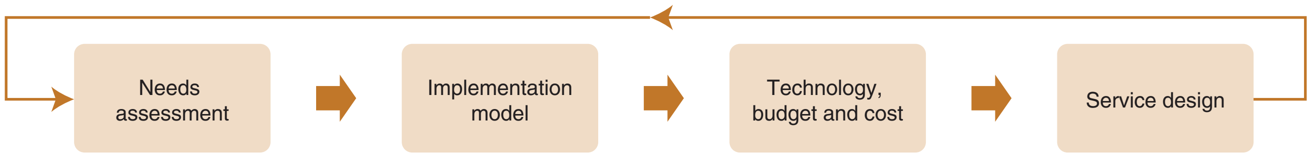
Efficient and precise data collection is an integral component of M&E of projects and programs. The enhanced ability to monitor, measure, and adjust to impact—through visualizing data on maps using GPS coordinates, accessing research published in previously inaccessible locations, providing rich information to farmers who could otherwise not be reached quickly, or recording beneficiaries who gain access to services—improves capacity to meet goals aimed at reducing poverty and improving productivity and resilience. This report identifies where ICT has expanded the capacity to perform good M&E and, more importantly, it identifies where it has not. It identifies where and how it can expand data collection and M&E, but also why and how technology is not a replacement for human agency and involvement in analysis and interpretation tasks.

The interest in deploying ICT for data collection and M&E has also led to a plethora of tools and platforms with a variety of capacities and constraints. The number of technologies applicable to data collection and M&E is daunting; hundreds of apps, software packages, platforms, services, features, and business models exist and are constantly developing. Designs and implementation strategies vary. Costs range from open source and free to commercial systems and expensive. Not only does a practitioner have to learn how to use the technology and demonstrate it to staff and partners, he or she must also justify why a certain product was selected and paid for in place of others and consider its long-term sustainability and utility in generating tangible outcomes.

1.1 SCOPE

This report seeks to propose solutions to some of these questions concerning data collection and monitoring and evaluation. It is designed to be an operational piece that addresses how governments and practitioners can use ICT to improve their data collection and M&E efforts in rural development projects. Although the report focuses on agriculture and forest activities, the principles discussed can largely be extended to other sectors.

FIGURE 1.2: Framing the Use of ICT in Data Collection and M&E



The second section of the report focuses on the most important aspect of ICT use: articulating the needs of the project and users. The third section provides an overview of five models currently used to implement and integrate information technology into M&E efforts. The crux of the report centers on choosing the right product or set of products for the project, and it includes cross-comparative guidance on application features such as data validation, offline capacity, dashboards, and built-in analytics (see section 4). The service design section deals (see section 5) with issues inherent to the provision of public services, such as how to provide appropriate incentives for the participation necessary to sustain the program and why post-data collection efforts are critical to success. Along with these practical approaches to deploying ICT, the report describes five case studies on mobile-based data collection in the agriculture and forest sectors (see section 6). The conclusion section follows the case studies.

It is important to note that the logic of the sections in this report and the process suggested in figure 1.2 is an evolving one. The feedback loop is a critical component of any project that uses ICT, and updating technology and the service design that supports it is based on the trends in the sector, which are constantly shifting. Paying attention to this feedback loop increases sustainability and maintains cost-effectiveness.

1.2 SURVEY METHODOLOGY

The publication draws upon information sourced from over 20 companies that have developed widely used systems and apps for ICT-enabled data collection in rural areas (see annex 1 for a list of the tools referenced throughout this publication). The companies surveyed are those that have deployed their application or product in more than one challenging context and on a large scale. These companies were surveyed on 34 application features, including platforms used, dashboard analytics, interoperability between software, training required, GIS capability, survey limits, and data validation processes. After information was sourced from the companies, a series of product and or technology considerations for practitioners were developed. Additional sources addressing data collection in developing countries using ICT, such as the work done by Humanitarian Nomad,[5] were also consulted.

The case studies in section 6 describe how a particular technology was adapted for use in various rural contexts. This information was sourced directly from practitioners involved in the projects. Questions regarding technology selection, implementation of the project, challenges, and impacts were explored in each case. The cases were selected with the intention to provide practitioners with a diverse snapshot of how different data collection models and technologies have been employed to achieve specific project goals in agriculture and forestry.

As stated earlier, this is a dynamic field, and thus the features captured in this publication will evolve and change quite rapidly over time. To address this evolution, the information on applications generated for this publication is also provided and updated on a cloud-based public database developed by NetHope.[6] This cloud portal is intended to provide a space for agencies and organizations to research ICT solutions, exchange information on the quality of services provided, and share experiences. The portal maintains a searchable product catalogue that includes the applications discussed in this publication among many others. The portal also hosts discussion forums, user reviews, and accumulates case studies. Practitioners can access and use this database by going to http://cloudportal.nethope.org/supersearch/#q/keywords=&num=10&channel=products&orderby=relevance&sort=desc&category=37&&38&&27&inclusive_categories=yes&pagination=P0

5 http://humanitarian-nomad.org.

6 http://solutionscenter.nethope.org.

Chapter 2: ASSESSING PROJECT NEEDS AND CONSTRAINTS

With a plethora of available technologies with unique combinations of capabilities and features, assessing the needs for any particular project is the first step in selecting the right set of ICT tools. To decide whether a particular technology—or any technology for that matter—is useful or not requires clearly defining project goals and sector needs. Asking the questions typical to agricultural or forest projects are important before even considering the technology. For example: What is the project attempting to achieve? Who are the targeted beneficiaries? What data are important to collect? What do project leaders want to draw from the analyzed data? What is the best way to report the data for management and stakeholders?

The extensiveness of data collection and its method should be established before the project begins. If technology is determined to meet project and data collection needs, additional queries can be posed. These questions have to do with issues related to ensuring that beneficiaries are effectively reached and empowered through the use of ICT and as such are less concerned with the specifics of technology, such as connectivity, the length of battery life, costs, and offline capacity, and more concerned with timelines, whether the data collection effort is singular or reoccurring, and the characteristics of data users, such as literacy, technology trust, and exposure to surveying.

The questions in boxes 2.1 and 2.2 highlight key project and people needs that warrant consideration. These questions are by no means comprehensive but are meant to help assess project needs.

BOX 2.1: Project Needs

- *Data:* What types of data are required? (for example, deep understanding through narrative stories, one-word answers on a number of different questions, or a mix of these)

BOX 2.1: *continued*

- *Survey-based or another model:* What model does the project require? (for example, crowd-sourced information, environmental or supply chain information through sensors, satellite imagery, or surveys)
- *Level of reporting:* To whom will reports go, and how will they be used? (for example, multimedia for beneficiaries, dashboards that allow multi-stakeholder access, auto-generated reports)
- *IT resources:* Are the ones needed available, and from where? (for example, in-house software development, outsourced Software as a Service (SaaS) solutions)
- *Context:* What constraints are inherent to conducting projects in this environment? (for example, political conflict, inhibiting weather patterns, poor infrastructure)
- *Funding:* Are realistic cost estimates available? Have sufficient funds been allocated for this work?

BOX 2.2: People Needs

- *Availability of technology literate enumerators or beneficiaries:* How much training will be required to implement the data collection effort?
- *Availability of technology trainers and support staff:* Will resources to train participants be available, and for a sustainable price and sufficient duration?
- *Well-constructed team:* Can the project recruit and maintain a team with the diverse skill set required? Importantly, this includes specialists with the necessary sector expertise, professionals in methodology (for example, survey techniques such as random assignment), local experts with indigenous knowledge, and analysts who can outline essential questions and then perform rigorous diagnostics once data have been gathered.

Chapter 3: DATA COLLECTION IMPLEMENTATION MODELS

Upon outlining project and people needs and determining that selected technology is a good fit, an appropriate data collection model can be designed. Using frontline workers—either community-based professionals or selected surveyors—to collect information is the most common method of mobile-based data collection. In fact, almost all providers discussed in this publication use this method. This section outlines this method and other emergent models in data collection, including automated capture, crowd-sourcing, passive capture and data harvesting, and qualitative data analytics.

FIGURE 3.1: Community Meeting. Girl on Cellphone. Aurangabad, India.

Photo Credit: Simone D. McCourtie.

3.1 FRONTLINE WORKERS

Frontline workers are enumerators, surveying the local population or target group on questions of interest. Using frontline workers to collect digital data requires similar design efforts as traditional methods such as random sampling. Local enumerators may have limited experience with technology and survey methodologies, and they may thus require training in technology basics as well as survey administration in order to communicate questions and capture pertinent information accurately. A mobile application is one of many among the digital tools a frontline worker can use. Among its advantages is the ability to make changes to the forms that can easily, and in some cases automatically, update field surveys.

However, some projects with standardized forms and a large volume of data collection may benefit from digital pen technology, in which information is stored both digitally and on hard copy, which allows frontline workers to focus more on the interview process than technology. While digital and hard copy storage in this manner may be perhaps more familiar to people, the quality of the data collected can sometimes be substantially less than in mobile-phone-based systems that may allow for error checking at the source. Projects may benefit from testing data quality in one format versus another—that is, testing whether the mobile phone interface helps or hinders their particular data capture process.

3.2 AUTOMATED CAPTURE

Automated data capture through technologies like GPS, sensors, satellites, and remote sensing has been around longer than other models. However, only recently has it become affordable, accessible, and tailored to development specialists and developing-country governments (figure 3.1). Often GPS data are collected through the same applications that frontline workers use for household data. Records are marked by location data through a built-in or attached device. Modern smartphones and pocket cameras feature built-in GPS devices that allow geocoded photographs to be used as part of the M&E process, often for evidence recording purposes. GPS coordinates can also be used to log infrastructure points, such as farm location and size, or irrigated areas.

Sensors collect ecological data on soil, water, and other elements of interest. After installation, these are programmed to record data at certain times. This method, along with satellites, is especially useful for measuring changes over time. Satellites are most commonly used to monitor land use shifts such as deforestation and water patterns (for example, desalination, sea level rise), as well as production, such as yield output and rate of crop growth. However, raw earth observation data require high levels of analysis before they are directly interpretable or actionable information. Remote sensing technologies such as LiDAR mapping allow analysis of vegetation mapping, including forest structure components such as crown density, crown volume, stand height, and tree density over large areas. These data can be used to estimate more complex vegetation characteristics, including basal area, forest biomass, and forest volume, among others.

3.3 CROWD-SOURCING

With the advent of widespread mobile phone access, crowd-sourcing for data collection is another emerging method for data capture. Crowd-sourcing is accomplished by allowing, requesting, and empowering rural people to send in their observations, data, or information through their mobile devices (figure 3.2). This approach can be used for many different purposes in rural development. One common use is during crises and natural disasters. Data collection from the general public can also be used to help forest and agricultural authorities identify emerging trends and phenomena. Agricultural applications such as pest outbreaks are a major area for potential use, and in the forest sector, local monitoring of logging in forests can help reduce the prevalence of illegal logging. Crowd-sourcing allows individuals to contribute to the data collection process, making it more democratic and transparent, and also helps authorities to target their enforcement and prevention activities to areas of specific interest.

FIGURE 3.2: Women of Takalafiya Lipai Village. Niger.

Photo Credit: Arne Hoel.

While it has many applications, this method of data collection is not without significant challenges. It is often difficult to attract participation of a large enough number of people to capture adequate data needed for robust data collection. It may require heavy investment in continuous marketing and compelling incentives for participation. One particularly essential incentive is visible and timely feedback to the information provided; participants need to be confident that their contributions lead to action (see also section 5.2 on "Driving Adoption"). The utility of crowd-sourcing may also be limited by a lack of advanced phones that can send complex messages (of course, short message service [SMS] can be used when simple, short messaging is all that is required), illiteracy that limits participation, and high levels of error involved in gathering messages from uncontrolled submitters (for example, without surveyors or frontline workers), especially when participation is low.

Crowd-sourcing is one component in wider data collection strategies. It is essential that crowd-sourced observations are verified to ensure that deliberate or accidental misinformation is identified, particularly in rural contexts where large numbers of participants (compared with urban areas) are not there to provide an additional level of accuracy. Last, if law enforcement is helped by citizens' participation, as can be the case especially in forestry, it is essential that participants' personal safety is not compromised and that information remains truly confidential. If mobile devices are to be used in crowd-sourced data collection, it must be taken into account that already existing legacy mobile devices need to be supported by selected data collection system, be it SMS or form-based. (See also the discussion on technology support in section 4.)

3.4 PASSIVE CAPTURE AND DATA HARVESTING

Data that can indirectly reflect a change in consumer habits, needs, or economic status can be captured from mobile phone use patterns. For example, by analyzing patterns in mobile top-up amounts and usage, researchers have been able to detect shrinking incomes well before the release of official statistics on this trend. Another example can be the flood of data generated through mobile payments for subsidized and other agricultural inputs, which can allow governments and civil society organizations to better understand the use of these opportunities and the subsequent food production patterns. This can lead to greater preparedness for preventing or responding to food shortages. Data from mobile usage patterns can also be combined with other methods to create a more robust data collection strategy.[7]

3.5 QUALITATIVE DATA ANALYTICS

Analytical tools such as Sensemaker,[8] created by CognitiveEdge,[9] help quantify and analyze story-based data and use "stories" or reports from myriad sources: users, experts, policy documents, videos, and photographs, and then find patterns within these qualitative data. The analysis and associated visualizations are formed from micro-narratives to build a rich and diverse picture of the questions of interest. For example, this could include perceptions of the main problem or challenge, understanding of the purpose of the policy or intervention, opinions on who should pay, or the perceived impact of a particular program.

This method highlights perceived outcomes beyond the focus on outputs (for example, farmer adoption of new practices rather than the number of extension trainings given). Stories are collected by volunteer or paid enumerators, fed into Sensemaker software, and analyzed to produce visualizations and analysis. This method is not without its challenges—the cost of the software alone may be prohibitive for some projects, but for complex problems involving a diverse set of stakeholders, such as wildlife conservation efforts or forest community-related projects, these emerging qualitative analysis tools may be considered part of a broader M&E strategy to add a diverse human dimension to collected data.

Linked metadata automatically sourced and organized from multiple sources is another exciting form of an open data pooling initiative now also moving into agriculture space with a leading application of TotoAgriculture.[10] This movement has great promise for qualitative data collection, but it is still in its early phase, and the dilemma for agriculture is how to select locally relevant data from global sources.

7 http://www.unglobalpulse.org.

8 http://www.sensemaker-suite.com/smsite.

9 http://cognitive-edge.com.

10 www.totoagriculture.org.

Chapter 4: MANY APPLICATIONS, MANY OPPORTUNITIES: KEY CHOICES FOR ICT TO COLLECT DATA IN RURAL AREAS

With needs assessed and an implementation model designed, the team can proceed to selecting a specific technology, application, or platform. The selection process itself takes some attention. The digital opportunities available to practitioners working in the forest and agriculture sectors are far-reaching. Hundreds of applications exist, with varying connectivity capacities, hardware components, costs, and features. The proliferation of these applications, while certainly promising for development work, has also led to hesitation and confusion in selection, design, and implementation.

Practitioners must answer a number of questions in order to determine whether an application suits their project's needs. For example, are applications truly offline capable? What are the running costs of a data collection effort? Are dashboards secure enough to store sensitive data? How much training is required for local staff? What types of hardware offer GPS functionality? Are there applications capable of collecting thousands of data points? Answering these questions, among others—and before technology roll-out—are critical to the project's cost-effectiveness and success. Box 4.1 includes further questions to be addressed when selecting tools for a project, building on work of the Humanitarian Nomad Online Selection Tool.[11] This also includes taking into account existing capacity in both personnel and technology. (See annex 2 for a more thorough overview of product capabilities and considerations when making an ICT selection.)

Table 4.1 builds on the questions in box 4.1 and displays the multiple options available according to different product features. It is a helpful visual in thinking through options available for platform, capability, storage, analysis, features, and other important aspects of the technology being selected.

11 http://humanitarian-nomad.org/online-selection-tool.

BOX 4.1: Items to Consider When Selecting an M&E Tool for a Rural Development Project

- Are there data collection technologies already being used in the target country?
- What platforms are used in the target country?
- Have the mobile devices that will be used to collect data already been procured?
- What is (are) the type of survey(s) required: one-off or continuous?
- Is there an existing reporting/analysis/visualization tool in use (such as ArcMap, Google Earth, SPSS)?
- Are there opportunities to scale out existing systems?
- How much is it possible to align with the public service provider (for instance, in the agriculture sector)?
- Is an SMS based system required?
- Do the survey data need to be stored on your own servers?
- Is real-time synchronization from the remote field or field office location needed?
- Are forms in non-western Latin character sets needed?
- Do the staff who create the forms have a basic understanding of databases and data structures?
- Is it acceptable to pay for a service solution that would host the solution and facilitate installation and development of forms?
- Is there a need to collect and display spatial data on a map?
- What are the emerging trends in technology and methodology?

The data sourced from companies revealed a number of key distinctions between the applications available for data collection and M&E in the rural sector. It also clarified relationships between features of a given application (for example, more-complex data

TABLE 4.1: Product Features

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Proprietary	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

Note: The table shows different options available in the market and does not imply any specific combinations of features in columns or rows.

collection needs more higher-end hardware). This section highlights the top considerations when selecting an application for a project, such as connectivity, data input technology, budget and costs, analytics, data management, and stakeholder access.

4.1 CONNECTIVITY

Though major strides have been made in connecting last-mile, rural populations to telecommunications and broadband networks (figure 4.1), there are still many areas with unreliable connections. Practitioners and governments alike are often surprised to discover that mobile services are not feasible due to restricted telecommunications access. Innovative solutions to using ICT even in these situations are possible, but they require careful planning. On the opposite end, some rural areas are gaining access to broadband. This increases the potential to use smartphones in data collection efforts and relieves the need for offline tools and the transaction costs resulting from travel to "connected" central locations.

The overwhelming majority of providers surveyed have "offline capacity" (see box 4.2 for Digital Green's method).[12] This means that the mobile devices used have the option of collecting data and storing it, then subsequently uploading it to the central server or dashboard once an Internet or telecommunications network is within range. This is a good option for data collection efforts that involve enumerators because they often have to travel to a central location in any case. Crowd-sourcing efforts are different and are not typically successful if telecommunications networks are weak. Some applications offer specialized solutions. For example, iFormbuilder created the "thunderplug," a device that synchronizes data from multiple mobile handsets to a central location even without networks.[13]

FIGURE 4.1: Telecommunication Network. Cambodia.

Photo Credit: Chhor.

12 http://www.digitalgreen.org.

13 https://www.iformbuilder.com.

BOX 4.2: Connect Online, Connect Offline: An Open Source Tool for Tackling Poor Connectivity

In areas with poor Internet connectivity, uploading extensive survey data or media-files can be a debilitating challenge at the field level. To circumvent this challenge, an India-based non-governmental organization (NGO), Digital Green, has created an open-source platform, Connect Online Connect Offline (COCO) that enables people to use the application continuously, and only requires connectivity when a user is ready to synchronize with the global data repository. This customizable framework can be used to upload baseline survey data, photos, and videos from the field without the need of IT or Engineering staff.

Free download available at www.digitalgreen.org/technology.

Another consideration, along with connectivity, is whether a survey can be updated in real time. Survey uploads or changes must be done with a network connection (currently most applications transmit data over telecommunications networks, not broadband). However, there are differences in the levels of management. If using SMS to collect data, the administrator usually must send an updated survey to the data collector. If using tablets or smartphones, survey changes will synchronize automatically with the handsets (as in the case of Cropster).[14] There are middle grounds to these two options as well; for example, users are given the option to update the surveys. This allows them to finish data collection on one version of the survey and then update to the second version when convenient.

Connectivity and the need for data transfer should be the first considerations when designing an ICT-enabled data collection effort. The strength of networks will significantly influence the technology, application, hardware, and level of administrator involvement.

4.2 DATA INPUT TECHNOLOGY

4.2.1 SMS vs. Form-based Digital Data Input

Devices to be used in actual data collection are often determined by the needs and complexity of the desired data set. One significant factor is the physical screen size, which determines the amount of information that can be displayed at a time. Feature phones typically have smaller screens only capable of displaying one or a few questions at a time on a single screen, whereas smartphones and tablets can accommodate a larger number of questions with more descriptive question text. More complex answer structures, such as selection lists and tables, typically also require either smartphones or tablets. Form-based tools often also include skip logic features that allow for data from previous answers to be used to determine which of the subsequent questions need to be displayed and answered. Simple SMS-based approaches do not suit well if such questionnaires need to be used. It is worth noting that a form-based system may also internally use SMS as a data transmission channel, but such a setup typically has disadvantages on the costing side, as cost per character sent via SMS is typically much higher than when General Packet Radio Service (GPRS)/3G data connection is used. Usually an SMS-based system is assumed to use the regular SMS inbox/outbox system available on each and every mobile device in even the lowest price points.

4.2.2 Basic Phones, Smartphones, and Tablets

Most service providers are moving away from approaches that use basic phones toward those that use smartphones. This is because while basic phones have lower start-up costs, they have higher usage costs because SMS can be very expensive. Conversely, smartphones might be more expensive initially, but they do not often incur such high data transmission costs. The cost of these devices is improving, given dramatic drops in prices, and many older hardware products maintain compatibility with applications even after a new version has been released. In the same vein, smartphones are often easier to learn how to use than SMS. Whereas SMS data collection projects are forced to use code to fit information into the small text message format, many smartphones have intuitive touch screens. Tablets are also becoming more commonly used due to rapid price decreases. This is especially true for Android devices.

Some applications can run on multiple platforms and others are more restricted. Cropster can run on all platforms so long as there is an Internet connection. Freedom Fone,[15] on the other hand, can receive calls and texts (crowd-sourcing) from any platform, but surveys must be administered through Ubuntu 12.04 or Debian.

14 https://www.cropster.org.

15 http://www.freedomfone.org.

An additional component to selecting hardware is whether geographical data should or need to be collected. Most applications can be GPS-enabled. This feature is most often determined by the capacity of the phone or tablet used and therefore influences the cost of hardware. For example, Android, iOS devices, and other smartphones have GPS features built-in. Simple Java phones do not. Freedom Fone and FrontlineSMS,[16] which do not use smartphones, do not have GPS capacity. If location is absolutely critical but the phone used does not feature GPS, additional devices can be used to attach GIS information to each survey, although this method is time-intensive and prone to error.

4.2.3 Digital Pen[17]

In some cases, a mobile application can complement digital pen-based data capture. For instance, for a survey regarding livestock disease, surveyors may find that only 30 percent of households are experiencing livestock disease. In that case, a mobile application may be used to capture data on the 70 percent of zero-valued households, and dot-printed or color-coded forms only need to be used with households where there is an incidence of one or more livestock suffering from a disease. This combination allows for cost savings as well as a more descriptive feature set. Effectiveness of processes based on digital pen technology is also often challenged by the lack of automatic data validation capability at the source. Such capability can be made available when using other electronic input mechanisms (laptops, tablets, mobile phones). Also, digital pen battery charging should be considering when using digital pen–based solutions in remote areas.

4.3 BUDGET AND COSTS

Considering the project's budget as well as the costs of a given application or technology logically follows the connectivity analysis, as connectivity limits options regardless of the budget size. Integrating ICT commonly reduces the transaction costs of data collection, so in most cases, digitizing at least some steps of the process increases efficiency.

16 http://www.frontlinesms.com.

17 A digital pen is an input device that captures the handwriting of a user and converts handwritten analog information created using "pen and paper" into digital data, enabling the data to be digitized and uploaded to a computer and displayed on its monitor. The handwriting-capturing technology used by various vendors may be based on accelerometer, positioning assistant, camera, or trackball. Digital pens typically contain a regular writing pen so the output can be seen on paper, as with any pen. Depending on the technology used, the paper may be plain or specifically formatted using miniature spotted patterns.

BOX 4.3: Questions to Include: Thinking Through What Is Needed

> Despite the capacity of digital tools to capture lengthy surveys, questions should be kept at a minimum. The quality of data gathered deteriorates quickly if surveys are too long. Moreover, too much data makes analysis difficult and overwhelming; the original intent of the data collection is drowned out in efforts that attempt to tackle multiple agendas simply because the tool allows for it. Defining the scope of the project explicitly helps to narrow down the list of questions. Projects must therefore optimize for accuracy during surveys and interviews to achieve best results.

A number of cost and budget factors should be considered when choosing an application. The three most varying factors are hardware and associated platform, the level of complexity (and therefore the training and troubleshooting required), and the scope or scale of the data collection effort. The third factor is intuitive: the larger the scale, the higher the cost. Of course, there are a multitude of additional cost implications. A thorough bidding and selection process (see annex 3 for a costing template and a list of considerations) will help to clarify accruing costs.

The applications discussed in this publication have the capacity to collect substantially large amounts of data. Due to confidentiality agreements and "hands-off" business models, many companies are unable to provide specific details on the scope of certain projects. In general, however, the applications reviewed in this publication are capable of creating surveys with over 100 questions (and some with as many as 400 questions)—see box 4.3—and hundreds of enumerators (iFormbuilder, Magpi,[18] and Open Data Kit [ODK][19] reported projects that used over 1,000 enumerators). Tens of thousands to millions of observations have been collected in a single project. Clearly, the applications available are indeed capable of implementing scaled-up data collection efforts.

Cost is related to the platform used because of the hardware requirements and the costs associated with using them. It is important

18 https://www.magpi.com (Magpi was formerly known as Episurveyor)

19 http://opendatakit.org/

FIGURE 4.2: Platform Usage Based on Companies Surveyed, in Order of Frequency

ANDROID: ************** (14)

JAVA: *********** (11)

iOS: ****** (6, with others on their way in the future)

Blackberry: ***** (4)

Windows: ***** (4)

to note, however, that sometimes costs are accounted for elsewhere (for example, using a platform that is more intuitive for users will reduce the costs associated with training even if that device is more expensive initially). The most widely used platforms associated with mobile devices today are iOS, Android, and J2ME. The J2ME platform uses the cheapest hardware and is the most simple in capacity, however it does not provide many options that smartphones do. iOS and Android platforms, on the other hand, provide more complex functions, but they are also more expensive than a Java device. Blackberry and Windows are also platform options, but they are much less commonly used than the others. Figure 4.2 captures the platforms that providers use.

Costs can also come from a variety of other sources. The database host, management, training, and fees for SMS or data transmission services range in price. Whether the application comes packaged with other services like consultation also influences the price. Generally speaking, applications that are not SaaS will be cheaper, but they may require additional IT support or planning time and thus increase costs through staff hire. The important note here is that projects that use ICT to enhance their data collection or M&E processes still necessitate human involvement for design and implementation; this component will increase either the cost of the application or the costs supporting it. At the same time, integration of ICT systems needs to be built in existing and foreseen institutional realities to be sustainable. For example, the structure and sources of budget funding matter. Many agencies may be cash-poor but staff-rich, or there may be (donor) resources available for investment but not recurrent budget. It is important to consider whether investment and recurrent budgets can substitute for each other. This has an impact on technology choice as well; an agency may have staff for in-house implementation and support but not for payment for external services and licenses, or vice versa.

TABLE 4.2: Suggested End-User Training Package Time Estimates* for Specific Data Collection Applications[20]

LESS THAN ONE DAY	ONE TO THREE DAYS	FIVE TO SEVEN DAYS
DataWinners	iFormbuilder	Magpi
doForms	FrontlineSMS	TechnoBrain
Mobenzi	PoiMapper	Freedom Fone
Nokia Data Gathering	Esoko	
Open Data Kit	Cropster	
Text to Change	Freedom Fone	
EpiCollect	OpenXData	
	mKrishi	

Source: Product Survey 2012.
* If users are new to the technology, the amount of time needed to train may increase.

Finally, the level of complexity of the hardware selected (along with expectations of data collectors) will determine training needs and capacity building, which is often the most expensive—and most important—part of a data collection effort. Enumerators and self-reporters (crowd-sourcing) will need less training if they are using basic Java phones or their own phones. With more-complex devices, additional training is required. The most time-intensive training is usually needed for participants who are asked to perform administrative or dashboard tasks, especially if they are unfamiliar with the technology. Table 4.2 is a simplified estimate of the amount of time it takes to train data collectors on application or device use. Training needs will increase if someone new to the technology is charged with managing the administrative portal. Yet it is important that training not thwart enthusiasm for digital tools; most local participants learn and adopt these technologies with ease.

The survey used to gather company information in this study also attempted to estimate costs for each application. The companies surveyed were presented with a hypothetical situation. In its most basic form, companies were asked what it would cost to collect 8,000–10,000 observations using 50 enumerators in Kenya. Yet due to a plethora of options, presenting detailed information on responses has limited utility. In their aggregate form, packages that include training, hardware, and dashboards are estimated to cost

20 These and a range of other tools are profiled in the Nethope Solutions Center database: http://cloudportal.nethope.org/supersearch/#q/keywords=&num=10&channel=products&orderby=relevance&sort=desc&category=37&&38&&27&inclusive_categories=yes&pagination=P0.

less than $10,000 for almost all providers surveyed. An important lesson learned here—beyond the cumulative and generalized estimate—is that there is a multiplicity of options and customized solutions on the market even within companies that have well established and widely used applications. This means that articulating needs, context, and goals are indispensable tasks before contracting a provider. Without such articulation, costs cannot and will not be accurately assessed during bidding processes.

4.4 DASHBOARD: ANALYTICS, DATA MANAGEMENT, AND STAKEHOLDER ACCESS

The dashboard or portal, where collected data are stored and available for analysis, is a critical component to a data collection effort. All applications host the data somewhere, and where they host them—along with the data manipulation features offered, the platform's organization, and data output—affects the types of analysis, sharing, and reporting available to users. Two fundamental options are an off-the-shelf solution that might accompany the application selected or a customized system. Open source solutions like MySQL and PostgreSQL, as well as solutions created by a paid developer, are good options—depending on factors like budgets and needs.

The first and probably most important consideration regarding the dashboard is whether it is hosted on a stationary hard drive or in the cloud. In the past, many applications were installed and hosted on one computer. This made it difficult for multiple users to view the data. Most applications now offer their services in the cloud or will soon do so (FrontlineSMS, for example, is currently developing a cloud-based server). Some providers leave the stationary or cloud option open for administrators to decide. If selecting the cloud option, two important questions are how many people can access the data and how they will get that access. Some providers have restrictions on the number of viewers (such as Cropster, which only allows four users). Different applications also offer a variety of "usership" options: Poimapper, for example, allows one admin user to create others and assign them rights (for example, to create forms, manage data, and view data).[21]

Data output and management are also considerations. Different applications can export data to a variety of analysis and visualization software, and some dashboards have analytical software built in. Exporting to xls, pdf, Word, and csv are some of the most common analysis output options. Applications can also export to visualization software (if using GPS data) such as KML, Google Earth, Bing Map, and ArcGIS online. How the data will be used after they are collected should be considered before selecting an application. Table 4.3 shows the options for a selection of providers, demonstrating the many similarities in their export capacities.[22] For heavy analytical work, applications that export to STATA or SPSS may save time by removing the need to transfer data from multiple software. However, transferring data from one software to another is not all that difficult with solutions like StatTransfer.[23] As such, it could be argued that data formats compatible with many others, such as csv, are the

TABLE 4.3: Data Output Capacity and Software Integration

PROVIDER	TEXT OR PDF	XLS	CSV	SPSS	STATA	XML
Cropster	*	*	*	*		
DataWinners		*				
doForms	*	*	*			*
EpiCollect		*	*			
Esoko		*	*			*
ESRI	*	*	*			
Freedom Fone			*			
FrontlineSMS	*		*			
Grameen			*			
iFormBuilder	*	*	*	*		*
Kimetrica	*	*	*	*	*	
Magpi		*	*			*
mKrishi		*				
Mobenzi	*	*	*			*
Nokia Data Gathering		*	*			*
ODK		*	*			*
OpenXData			*			
Poimapper	*	*	*	*		*
TechnoBrain	*	*				*
Text to Change			*			*

Source: Product Survey 2012.

21 http://www.poimapper.com.

22 These and a range of other tools are profiled in the Nethope Cloud Portal database: http://cloudportal.nethope.org.

23 http://www.stattransfer.com.

TABLE 4.4: Spatial Visualization Tools

PROVIDER	KML	BING	ARCGIS	GOOGLE
Nokia Data Gathering	*			
DoForms	*			
Kimetrica		*	*	*
Magpi				*
Techno Brain		*		*
Poimapper	*		*	*
Mobenzi		*		*
iFormBuilder			*	
ODK	*			
EpiCollect	*			*
ESRI	*	*	*	*

Source: Product Survey 2012.
Note: Cropster plans to integrate ArcGIS in the short-term.

ideal formats to choose during application selection. Companies do offer customized solutions and are sometimes willing to develop a new tool or process (such as exporting to a different software) if requested. Thus this area of functionality is in constant evolution.

Visualization and data representation can play a major role when using data to argue for change, which makes the use of spatial data relevant. There are a number of spatial tools to map data through GPS. Spatial visualization software includes KML, ArcGIS, Google Earth, and Bing. Table 4.4 shows the providers that integrate this type of software into their application and dashboard directly. Some applications, like Poimapper, can export to other visualization software if licenses are purchased.

Dashboards also have a range of additional features. Providers offer a variety of other reporting or analytical tools within the dashboard itself. However, because most applications allow data export to relevant software like Excel, some reporting features can be considered more or less bonuses. The DataWinners dashboard provides the user with basic calculations (sum, average, min, max) for quantitative data,[24] FrontlineSMS offers chart views for polls, and Mobenzi integrates chart-making for reports into their system.[25] These features are not as critical as other features, such as capacity to record spatial data or record data offline, but they could save time for projects that require more-rapid analytical output (for monitoring during different project phases). A common but important application function is "search." Searching or organizing data in the dashboard (or setting parameters to do so) by date, contact, and survey question, among others, reduces the manual data manipulating often needed for analytics.

Kimetrica is a special case, as it offers end-to-end project management especially designed for M&E needs, which makes it a versatile platform for generating standardized national, policy, or project-level metrics.[26] The system interfaces with Google Earth, and at the same time users can overlay country administrative maps. The system comes with administrative maps for every country in the world down to administrative level 3. It also allows users to upload their own administrative and EA maps. Kimetrica also includes a large number of routine data entry and field enumeration management functions that make it easy to monitor survey performance and progress in near real time.

4.5 ADDITIONAL FEATURES

There are special features of applications that may save time and be critical to certain M&E efforts. The first is whether an application has signature or photo capacity. Recording signatures can be useful for a variety of projects, but it is particularly useful in data collection efforts that may require participants to confirm or acknowledge their involvement or the release of their personal data. Photos can be useful in smaller data collection efforts that are designed to record case studies or personal anecdotes. They are also useful for projects that require identification (for example, data collection for subsidized fertilizer to selected farmers).

Put simply, smartphones have these features and Java phones do not. However, just because the device has the capacity does not mean the application can logically store and organize the photos or signatures. Twelve out of 20 providers surveyed have photo-taking capacity, but only 4 out of the 20 have signature capacity. Most providers have plans to offer both services in the future.

Interactive-voice records (IVR) are also an important feature of digitized services in the agriculture and forest sectors, but they are

24 https://www.datawinners.com.

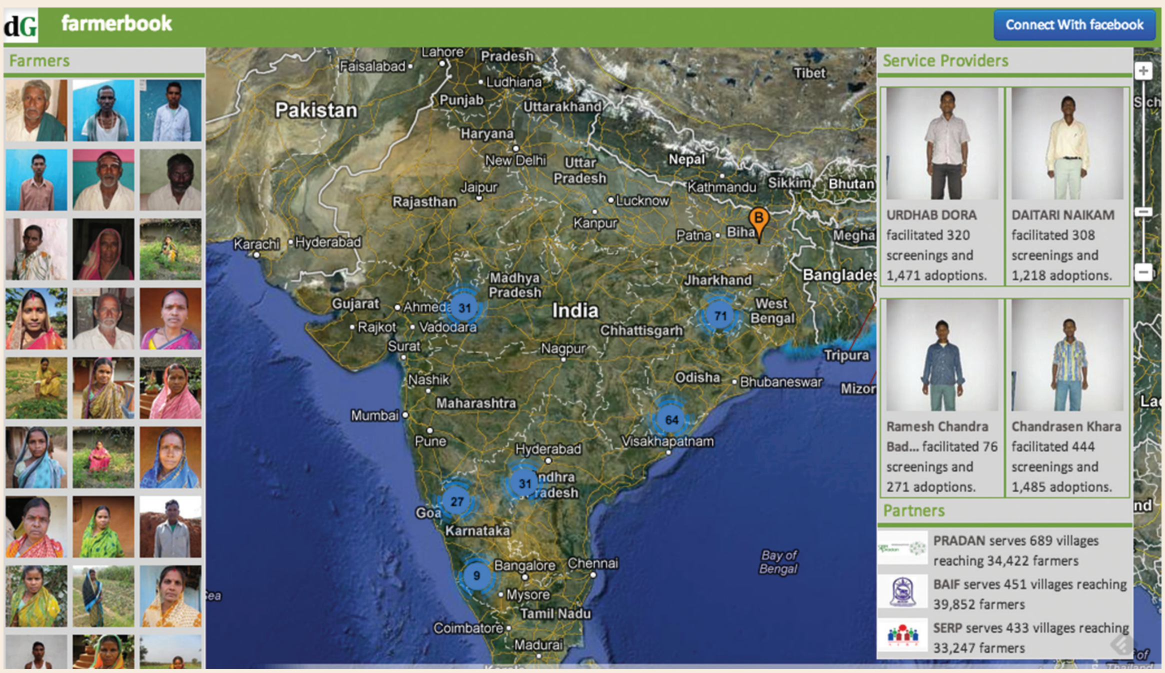
25 http://www.mobenzi.com.

26 http://www.kimetrica.org.

not as relevant to data collection efforts. The primary purpose of including IVR in applications is to give illiterate users access to the same information as people who can read text messages. Users can call a specified number and select pre-recorded options to receive information on important farm practices, for example. Though data collection through IVR may not be feasible due to airtime costs and difficulties with research methods in rural locations (for example, selecting certain geographically located households based on a representative sample size), disseminating the results of data collection efforts through IVR could be a practical way to get analyses back to local stakeholders.

Some of the best M&E programs collect client or beneficiary information at the individual level, in aggregate forming a rich, detailed database of work completed. Digital Green has gone a step farther to connect geographical and user data through *Farmerbook*—a visual geo-mapped database to provide a connection between end clients, service providers, partner organizations, donors, and the general public. (See box 4.4.)

BOX 4.4: Digital Green's Innovative M&E Data Reporting Model



The main page of *Farmerbook* features the leaderboards of the farmers, community intermediaries, and partner organizations. A different metric, called adoption rate, ranks community members, facilitators, and partners based on the percentage of practices they have adopted relative to the total number of extension videos they have viewed. A more composite metric, based on attendance rates, screening frequency, and adoptions, is used to grade the villages, depending on their level of activity and performance. This feature is meant to stimulate some healthy competition among service providers and communities to improve participation and adoption.

The timeline view on a village or individual allows users to see the integrated nature of the practices that farmers are watching and how their questions, interests, and adoptions change over time and how that relates with other members in their community. *Farmerbook* images of farmers and service providers also connect with Digital Green's Facebook game Wonder Village, which brings Digital Green's work with rural communities to a wider international village.

In addition to this user-centric view, the organization's analytics dashboards (http://analytics.digitalgreen.org) share aggregate statistics and visualizations of these data along time, geographic, and partner-based dimensions and "Our Videos Library" (http://videos.digitalgreen.org) shows these data from a video-centric perspective to identify videos that are most or least viewed, adopted, and queried to improve content quality and relevance.

4.6 INTEROPERABILITY

Data exchange standards allow organizations to share data within their own bodies and with external data experts and stakeholders. Although it is not a specified feature of a given application, the level of desired interoperability—or the capacity to easily transfer data and outputs to various systems and dashboards—should be considered, as it prevents convergence complications in the future. Complications could, for example, be derived from an attempt to aggregate data from similar surveys conducted in different regions. Without data exchange standards and formats, governments and agencies cannot effectively share data or add to analysis across departments. Surveys must be "reinvented" when applications use specialized software that is non-transferable to other types. For large development organizations, this is highly problematic and leads to the same inefficiencies found in simple, paper-based data collection. Not only is maintaining and requiring the same data standards critical to the sustainability of digitized processes, it also has substantial payoffs when tools can be used or built in from other projects. All new initiatives, and even ongoing ones, should consider the interchangeable nature of their systems—and attempt to make them increasingly open to sharing and transferability.

Formhub, for example, uses the industry standard open-source application, Open Data Kit (ODK), which uses xls forms (Excel). Using ODK Collect through formhub allows users to build surveys through an Excel file, upload them onto formhub, and download them onto enumerators' phones, where data are then transferred to an xls-compatible server.[27] This solution takes some learning, is free, and, importantly, maintains common standards throughout the data collection process.

Due to the increasingly recognized importance of a total ecosystem approach and interoperation, many providers are using the Software as a Service model. These are services that require no additional investment in infrastructure outside of purchasing the end-user device. Even maintenance and technical support is included in fees. In cases where in-house IT support is limited, these models can be great solutions. It is important to note that although costs over the lifetime of the SaaS tool usage may seem at first higher than the up-front cost of single-provision tools (for example, an application or a database), the latter often excludes maintenance and technical support. However, customized solutions do also require continued IT support after initial provisioning, and as these services are often separately sourced at a later stage, the overall cost may also be quite a bit different. Practitioners should therefore carefully weigh the benefits of a bundled off-the-shelf approach against a more customized solution.

One final note: not all projects necessitate interoperability. Many organizations that have pioneered ICT in their projects, such as Catholic Relief Services,[28] have tried many options and are now increasingly converging on a centralized model in order to have comparable, standardized data across the organization.

4.7 TECHNICAL SUPPORT

Technical support is crucial to new ICT4D projects, and it can vary widely among different service providers. Some companies include tech support in their fees while others do not. Open-source applications do not normally maintain a strong technical support team, and users are often left to their own devices to solve problems. Community forums are one way users have answered questions and resolved issues. However, forums do not always lead to timely or sustainable solutions. IT teams that can provide regular, expert solutions to technical problems like coding error are critical to projects that use free applications. It is important to realize that using open-source applications does not automatically mean there is no cost involved throughout the full life cycle of deployment of such application software. Open Data Kit is a good example. Underlying software is offered free to use, but the operational model may require support from either service providers or an in-house ICT team. This makes up the business model for the service providers.

4.8 LANGUAGE CAPABILITY, SECURITY, PRIVACY, AND DATA VALIDATION

As development specialists begin using technology in their projects, there are always a variety of concerns raised, one of which is language. Oftentimes, common languages like English, Spanish,

27 http://formhub.org.

28 http://www.catholicrelief.org.

French, and Arabic are not useful in initiatives in rural spaces. Technology needs to support local and indigenous languages; even if local people are not directly reading or responding to messages (which is sometimes the case due to illiteracy), enumerators who collect the data normally speak local languages. Fortunately, many applications can master most languages. iOS products support 34 languages, and many applications can spend a few days to customize systems to support specific languages. The most common restrictions to language capacity is the platform, where data are hosted along with the data visualization and stakeholders' access portal or dashboard.

Two additional common concerns are viruses and data security. While both concerns are valid, the virus-related threats appear limited, according to service providers. None of the companies queried report that they have had problems with viruses. Viruses are more common in situations when computers or laptops are connected to the Internet. If users download items from the Internet or their e-mail, a virus can be included. These threats should be considered and prevented through the use of firewalls and other means if using these types of tools.

Data security is another problem, one that most service providers have overcome by providing hosted services. If data are hosted at a client's own data center or sometimes even stand-alone servers, the security of the whole hardware may become a concern. Encryption, login passwords, and backups are all used to protect sensitive information. However, in some circumstances the computer systems may be compromised and data can be unlawfully decrypted with adequate computing resources in a certain amount of time. Use of non-common passwords at all levels is usually a good measure to help make this type of attack less successful. Thus the information is still only as safe as the hardware and the physical environment it is stored in. Another aspect related to data security is data safety, the overall end-to-end system reliance against data becoming accidentally or deliberately destroyed. This could happen simply because of human error or because of systems or hardware failure or even disasters such as fire or floods. To deal with challenges related to data security and safety, it is important that proper backup capabilities and, if necessary, disaster recovery strategies and procedures are in place and in active use. Service providers offering hosted services usually have taken measures to offer these functions as part of their service.

SMS is a feature most prone to security challenges. Technically the SMS security is often compromised not at the mobile network level that is used to transport the SMS messages, but at the end-user device usage level. For instance, sent messages are usually stored in the device and are accessible to anyone gaining access to it unless the device usage itself is controlled by security measures such as PIN codes. FrontlineSMS, a service provider that maintains that the best protection comes from user care, recently published a guidance note on data security.[29]

Privacy in the context of data collection can be seen from at least two perspectives: privacy of the collector or enumerator and privacy of the data collected. In the former, the main concerns are protecting the identity of the party collecting the data, be it crowd-sourced or a frontline worker. For instance, when data gathering is used to provide field information about activities such as illegal logging or unlawful land use, it must be ensured that the information cannot freely be linked back to the person reporting it. In case of privacy of the data, the collected data may contain sensitive information such as personal details. Therefore proper mechanisms must be put in place to limit or possibly prohibit access to identifiable pieces of information in the collected data set.

Data validation—making sure that errors are caught and corrected—is another issue that practitioners are concerned about. However, service providers have discovered and used methods that control potential problems with errors. For example, many applications have skip conditions (for example, if a respondent is male, and there are questions specific to females, the survey will "skip" over the female-related questions), automatic date recordings, specified ranges for numerical questions, and constraint validation (which does not permit the user to go to the next question if blank values exist). Applications also use built-in mechanisms to prevent numbers or letters from entering certain spaces (by specifying the

29 http://www.frontlinesms.com/user-resources/user-guide-data-integrity.

"type" of information to be entered), multivariate validation (which prohibits implausible combinations of data), and the prevention of double entries. Most applications will not allow users to input or send data that falls outside of the specified criteria. Not all applications offer the same range of data validation tools. These are important questions to ask providers, particularly when data are complex or sensitive.

ArcGIS also provides tools to help validate user data. Users can apply topology-based validation to make sure that features conform to pre-determined spatial restrictions. Users can also define coded values, domains, or subtypes to restrict attribute data to specific choices, helping you maintain data accuracy. Additionally, you can create and use feature templates to streamline data creation by defining required attribute fields, default attribute data, and default symbols.

Chapter 5: SERVICE DESIGN

It is widely acknowledged that technology is not a stand-alone solution in most development settings. The most successful application approaches develop and design integrated systems—making the mobile application, hardware, backend software, dashboard, and sharing mechanism, as well as the collection methodology, and field worker incentives, all key aspects of the overarching data initiative. In addition to the technology infrastructure, a strong service design is needed to ensure that the technology will be adopted widely, add maximum value, and be sustainable beyond the initial stages. This section addresses three of the most important components in effective service design: thoughtful analysis, ensuring adoption, and managing risks. Just like in the design and implementation of development programs that do not use ICT, these components—the human components—remain critical.

5.1 WHAT ICT CANNOT DO: THOUGHTFUL ANALYSIS

Technology is not a stand-alone solution for M&E. Even after selecting, building, and deploying the technology, successful projects require human capital to translate the data into meaningful inferences and to decipher development implications. Statisticians and methodologists, who are trained to accurately derive conclusions about causality and outcomes, cannot be replaced by technology. Moreover, it is dangerous for organizations working in this space to believe that technology can be used for deeper analysis of the data.

Local M&E expertise—or capacity to correctly obtain conclusions from data—may be difficult to find and retain. Practitioners should therefore include the hire of analysts within their project plans and budget. Skilled analysts are not just required when data have been collected. As in projects without ICT, they should also be included during survey design, sampling methodologies, and other advanced evaluation processes. Similar thinking should accompany processes to report data and analytics back to relevant stakeholders. Communication experts are useful in tasks that involve the provision of feedback.

5.2 DRIVING ADOPTION

As in any landscape project or program aimed at improving livelihoods, long-term adoption by users and by those urging uptake of new technologies (for example, community extension workers) is both critical and often challenging. The use of ICT does not automatically overcome these inherent challenges. However, there are solutions to adoption barriers. Many of them that are centered on the structure of incentives are similar to those used in projects that do not use ICT. These strategies to increase sustainable adoption most closely apply to frontline workers who implement the survey, but their application can also be extended to other users, such as those involved in crowd-sourcing efforts.

5.2.1 Adding Value to the End User

In projects where extension officers and community professionals carry out trainings, mobile-based data collection applications can help isolated service providers to structure their work and to obtain fact-based feedback regarding their performance. By giving them targets and making them feel part of a larger effort with achievable benchmarks, features that send analysis back to service providers could provide a better context and connectedness, especially in rural projects. This value can also support and sustain continuous use of data entry systems. Moreover, training that focuses on "why it matters" and how the data are used is crucial to motivate field staff to strive for the most accurate results.

5.2.2 Properly Characterizing Users and Clients in Projects

Many agricultural applications deal directly with farmers and other end-users of information and services. In forestry—and in forest governance and resource assessments in particular—the situation is often different. Often forest sector development interventions aim at influencing the performance of the forest institutions and agencies as well as the forest users directly. Therefore public sector information management is the focus, and forest users are indirect clients of development investments. Consequently the data collection methods and incentives are different. In essence, action often happens at the "wholesale" rather than "retail" level.

This has two specific implications in forest sector data management and M&E: First, it is essential that data and information flow in two directions; information dissemination on forest resources and agencies activities is just as important as information collection from the public. Second, in public administration and service delivery, the assessment of sustainability differs from private transactions. Assessing sustainability from the perspective of a private transaction and financial revenue capture is not enough. Public services cannot be assumed to be entirely self-financing.

One final comment on characterizing the users and clients involved pertains to participation. Participatory design—that is, piloting, and user-testing software with actual users—creates a product more likely to be adopted by taking into account uniquely local constraints and perspectives.

5.2.3 Rewarding Excellence

Projects have various incentive structures for frontline workers, hired exclusively as enumerators to collect survey data or as service providers who also collect data on program participants. These structures may include a lump-sum payment or a fee per day of data submitted. Some projects, such as the Sustainable Agriculture project of the Society for Elimination of Rural Poverty (SERP) take a different approach. SERP's project provides a base salary plus a substantial performance bonus (30–50 percent of the monthly salary) for sending in complete, accurate data sets 90–95 percent of the time. This strategy is highly effective in aligning incentives between the organization and the frontline staff in improving data quality and building capacity.

5.2.4 Providing Non-financial Incentives

Training and improving employability for future opportunities by obtaining experience is often a big incentive, especially for younger enumerators. (See box 5.1.) Targeting women and minorities in the selection process also provides opportunities for those traditionally excluded from gainful employment to gain marketable skills and experience. For community professionals, incentives such as visibility and prestige, as well as the motivation to work on hardwired challenges in their communities, can be a major driver, especially on community-driven development projects.

5.3 MANAGING RISKS

A final component of service design is the management of risks. Mobile-based data collection has a great number of benefits that makes information transfer automated and efficient, as well as rich with the use of location data and photo capabilities. But data collection technology is only as good as the information that is collected and the abilities of those who collect it. Therefore, accounting for risks is imperative during both service design and implementation stages.

5.3.1 Misplaced Focus of Training Programs

Even paper-based data collection requires rigorous training of enumerators in eliciting information from target individuals and households. With a mobile interface that could potentially distract from the data collection process, this training becomes even more essential. As projects turn to mobile and digital technology, training must focus on not only the technology itself but, more importantly, on helping enumerators understand the context of the project and how the information they collect will be used in order to enable them to focus on accurate results.

5.3.2 Context Matters

In switching from manual to mobile-based data collection, it becomes easier to coordinate and track field staff—such as extension workers. When these data begin to be used to judge performance of field staff without offering added value in the front end, location capabilities can remove autonomy and the project can subsequently suffer from lack of adoption.

One example of this is when mobile applications capture information regarding attendance at agricultural trainings. The attendance could also be a factor that the frontline worker does not necessarily

BOX 5.1: Boosting Non-financial Incentives and Decentralized Collaboration through Social Media

Aggregating buyers and producers of eco-friendly organic produce, the Association of National Ecological Producers (ANPE) in Peru has integrated youth involvement and social media tools to promote decentralized coordination and local ownership and as an added marketing platform to create effective demand for regional *ecoferias*.

With the financial and advisory support of the International Institute for Communication and Development, the organization has embarked on a three-year pilot that currently works with 45 young facilitators and over 500 organic farmers selected from local communities to collect data from farmers regarding supply and in turn facilitate marketing and business decisions.

As the project covers only costs of traveling to the *ecoferias*, much of the incentive for participation is non-financial: the opportunity to learn and gain experience, a chance to expand their networks and obtain exposure to their peers and to external organizations and farmers, and recognition through programs on rural radio and through their commitment and involvement, which gives them a more active role in their associations and families. The young facilitators, who are also organic growers, get the chance to promote their own products in the *ecoferias.*

In line with this strategy, the project has leveraged growing rural access to the Internet in order to use social media tools such as Facebook and You Tube in two main ways: to provide an opportunity for exchange of ideas and information among youth facilitators and opportunities for leadership and recognition and to position the "Fruits of the Earth" brand to attract new customers and improve consumer awareness of eco-conscious consumption.

The project is currently in its third year and has begun scaling up to three more districts in Peru. ANPE is striving to make the ICT initiative and youth involvement sustainable through partnerships with both the Peruvian restaurant industry and exporters of organic products.

Additional Resources:
ANPE Peru http://www.anpeperu.org/
Frutos de la Tierra – Ancash https://www.facebook.com/Frutosdela TierraAncash
Frutos de la Tierra – Caramoja https://www.facebook.com/FrutosDeLa TierraCajamarca

control. With real-time feedback, if this information were to judge the service provider's performance in a vacuum without taking into account the relevance and usefulness of the program and the local context, it could become a disincentive for workers to continue to send in information. The section on improving adoption addresses how adding value that empowers frontline workers with feedback and information, coupled with incentives for improving performance, can increase adoption of mobile-based interventions, especially at scale.

5.3.3 Efficient Cheating

In a different setting, where manual systems had previously required signatures or thumbprints of participants and where locations are not mapped to field sites, suboptimal usage of the capabilities of mobile applications could make cheating more efficient and could lower the ethical barrier for reporting fictional entries. Programs are especially vulnerable to poor data of this kind if incentives for adoption are misaligned. Requiring geotagged or photographic evidence that is checked randomly could help with these problems to some extent, but the problem can ultimately only be addressed by ensuring that the application adds value to the end user, provides resources necessary to compensate performance, and enables rather than undercuts the autonomy of service providers. Another method to improve accurate reporting is cross-validation methods that double-check data for red flags and ensure system-wide quality. For instance, attendance at trainings that does not correlate with adoption rates might be an indication of false reporting. Peculiar data should automatically be flagged and brought to the attention of project coordinators.

On the other hand, mobile applications can also provide additional controls not available in traditional processes, such as automatic location recording, time stamps, and timing of form filling process even to the level of time taken for an individual field to be completed. Later analysis of such data (for instance, assessing the distribution of time taken per field over larger number of forms) may provide additional information to help identify occurrences of potential cheating. Tying incentive mechanisms to correct submissions of data can enhance the quality of the data collected.

It is important to ensure that when ICT is considered in place of a traditional pen-and-paper system, the control mechanisms need to be put in place equal to or better than those of traditional M&E systems. If signatures were required according to traditional processes, geotagged data or digital signatures would need to be required in an ICT-based approach as well. If cheating was of concern, tools that provide relevant detection mechanisms should be used. Similarly, the acceptance of data may require a gatekeeper role with authentication (signatures), and so on. All such aspects would need to be designed into the model properly when considering use of ICT in place of traditional M&E tools.

Chapter 6: CASE STUDIES

The following case studies capture the experiences of organizations—from large to small—that have developed and used technology innovatively for data collection and M&E. They have been selected to highlight a variety of off-the-shelf, open source, and customized software solutions, as well as innovative service design that highlights the best practices in implementing ICT in agriculture and forestry. The case studies also highlight the diversity in scale and the challenges faced by organizations in achieving sustainability beyond the project period.

6.1 SUCCESSFUL RELIANCE ON TRIED AND TRUE TECHNOLOGY—THE INTERNATIONAL SMALL GROUP AND TREE PLANTING PROGRAM (TIST) IN KENYA[30]

Properties of Featured Technology: *Palm, PDA, external GPS, custom installation, frontline workers, proprietary, in-House, online, two-way sync* (see also annex 4).

Context

For more than a decade, Ben Henneke has been helping people in Kenya plant trees to support both the environment and farmers' incomes. His organization—The International Small Group and Tree Planting Program (TIST)—developed technology specifically designed to verify the progress made in planting and tree growth in TIST project areas. Henneke knows that tree planting can provide economic as well as environmental benefits only when measured correctly and that his organization's work can make a considerable difference to the livelihoods of small farmers.

As in many countries, Kenya has experienced rapid deforestation over the past several decades. The Kenya Forestry Working Group attributes deforestation to the energy, tourism, agriculture, and tea industries. The country's forest problems were brought to light in 2004 when Wangari Maathai, founder of the Green Belt Movement, won the Nobel Peace Prize largely in recognition of her work supporting peace and stability through tree planting.

TIST focuses on teaching farmers tree planting techniques that, by design, propagate from person to person, and it uses well-worn data collection technology to measure and monitor the progress of the incremental growth, root mass, and health of the trees these farmers plant.

Project

In addition to training on irrigation and beekeeping, TIST trainings cover planting and caring for indigenous tree species as well as fruit and nut trees that could help diversify residents' income. Henneke said that the TIST technical approach is entirely based on organizing local groups whose communal interactions help ideas travel by word of mouth. The demonstrably useful techniques, shared by one neighbor to the next, have successfully led to the planting of a diverse range of economically and environmentally important trees. As an example, in the Meru District TIST has predominantly supported the planting of eucalyptus, grevillia, cypress, mango, acacia, avocado, mukwego, cordia africana, macadamia, and orange trees. According to TIST, so far approximately 4.5 million of these trees have been planted and 1.7 million seedlings have been raised.

The community reforestation activities provide residents the benefits of generating income from the carbon credits earned from the trees they have planted. Approximately 100 TIST field monitors (called "quantifiers") follow the UN Framework Convention on Climate Change standards for Monitoring Afforestation/Reforestation by Small Groups or Individuals to measure the carbon sequestered

30 http://www.tist.org.

by the farmers' trees. Carbon values are verified according to the standards of both the Verified Carbon Standard (VCS) and the Clean Development Mechanism (CDM), allowing the Kenyan farmers to receive annual payments for the certified emission reduction credits they have earned. TIST, which operates similar programs in Uganda, Tanzania, and India, expects its programs cumulatively to sequester 5 million tons of carbon by 2020.

Challenges

TIST faces the challenge of making its work relevant to a large number of small farmers who may have only planted a limited number of trees. Holdings of "0.04 hectares are the reason we set out to do this in the first place," Henneke explained. Still, their numbers are massive. There are approximately 45,000 individual plots that are owned or managed by TIST members in Meru and Nanyuki near Mt. Kenya, the two areas where TIST operates.

The extensive field monitoring and amount of data involved, together with the stakes involved for subsistence farmers, have raised the incentive for TIST to efficiently and accurately collect data. The supplemental earnings from accurately tallied carbon credits provide the farmers with a cushion against the vagaries of weather or price fluctuation.

In order to map the location of specific trees and specific tree species, and to capture tree volumes for carbon credits, TIST has long used stand-alone GPS devices in combination with older Palm Centro 680 and 650 and the Zire 71 mobile devices for data collection. The Palms are no longer for sale via the usual channels (TIST finds them on secondary markets at a discount), but they continue to function well and with low operating costs. "We can outfit someone for 150 bucks," Henneke explained.

The data on trees and tree groves are collected in person using the Palm devices, with trained enumerators filling out set forms with details of tree type, health, and measurements. Diameter is measured at breast height (1.3 meters/4.27 feet). The quantifiers use formulae to calculate the biomass of large stands of trees. Three-quarters of the enumerators are men, most who come from the provinces where TIST works. They are trained repeatedly, and their field calculations are audited.

In Kenya alone TIST is tracking 39,000 individual tree groves. The organization states "present models show that the trees planted … should achieve between 500,000 tons and 3,000,000 tons of CO2 sequestration."

In order to meet its data collection demands, TIST developed its own phone-based forms in C++ as well as software for receiving and sorting data. Information sent in from the Palm devices is automatically sorted into searchable databases. Henneke said that over the years TIST has mined these data very successfully to identify trends and needs for further interventions.

Perhaps surprisingly, power rather than software has presented a more significant challenge because quantifiers are often in the field away from mains electricity for days at a time. More than once TIST has demonstrated an ability to "hack" power systems—using the old, positive meaning of the word. Some computer equipment that TIST formerly used would lose all its data when it lost power. To keep the Palm devices working longer in the field, TIST quantifiers use "pigtails," which are four rechargeable AA batteries wired into one circuit, then taped together and plugged into the devices.

Solution

The beauty of TIST's customized, even if dated system, is that it has continued to work reliably well beyond the expected expiration date. The mobile data collection devices have kept functioning for several years, and the custom software has required minimal updates. Henneke said they have studied other, open-source data collection platforms, particularly those that operate on the Android operating system. Yet they found the alternatives lacking in the specific functionalities TIST needs in the field.

Although they are not using enterprise-level data collection tools, they present a counter-narrative to free and open-source protagonists: If we build in only the functionalities we need, to our specifications, we save time and money over the long run. Typically, customized, proprietary software is associated with high cost and unsustainability. Open-source tools, on the other hand, are extolled for the ability of a community of volunteer users to refine and advance a tool that anyone can use.

Yet even paying for a staff person who would be a part of a particular open-source community for the sake of TIST exceeded the long-term sustainability plans of TIST. Rather than demonstrating the most modern technological gadgets work in the field of forestry, TIST demonstrates how forest projects can be successful when they are "scoped" according to local financial capability realities rather than built upon large but temporary international organization budgets. TIST eschews what Henneke considers to be typical development project expenditures, emphasizing project spending levels that will be sustainable after his project funds end.

Eventually the organization developed its own site that was optimized for mobile phone screens, allowing quantifiers to query the database from the field. As of summer 2012, TIST's custom platform began providing information on tree grove names and location in relation to a quantifier's physical location. This information has proved especially interesting to the farmers with whom the quantifiers interact.

TIST uses the data primarily for two purposes, both of which are related to carbon credits. First, the organization wants to use the aggregate numbers to demonstrate and promote the cumulative effect of its tree planting work. Second, TIST wants to help individual farmers receive remuneration from global carbon credit schemes, no matter how few trees they have planted. For both aims, TIST adheres to VCS and CDM.

Yet as their devices wear out, TIST faces an inevitable challenge of updating the hardware and software of its operations. Ben Henneke said that TIST is now changing its data collection forms often enough that they have initiated a migration to HTML5. This will eventually mean updating devices, re-training quantifiers, and heavily modifying their database platform.

Henneke downplays his organization's role, emphasizing that "the trees do all the work." And rather than looking to buy the latest devices, he continues to find that developing the capacity of farmers—"human technology," as he calls it—is the best possible investment TIST could make.

Source:

Ben Henneke, Director, The International Small Group and Tree Planting Program, interview on 8 February 2013.

6.2 FAO'S OPEN FORIS INITIATIVE—INTEROPERABLE, MODULAR MONITORING, AND EVALUATION TOOLS FOR FORESTRY[31]

Properties of Featured Technology: *Android, smartphone, GPS, external GPS, frontline workers, open source, online, offline, two-way sync* (see also annex 4).

Context

Inspired by the idea of harnessing ICTs to dramatically enhance forest management globally, in 2013 the Food and Agriculture Organization (FAO) is concluding the first phase of its Open Foris Initiative, an effort to empower national and subnational forest agencies to collect, process, analyze, and share forest resource and related socioeconomic and governance data.

According to FAO, 80 percent of countries face difficulties acquiring data and reporting on the state of their own forests due to a lack of organizational capacity, particularly with ICT tools. These countries are particularly vulnerable to illegal logging, environmental degradation, and threats to wildlife. To address this issue, FAO has committed to supporting 30 countries, and Open Foris tools are already being used in Ecuador, Indonesia, Paraguay, Peru, Tanzania, Vietnam, and Zambia. Soon they will start working with forest management bodies in Bhutan, Mongolia, and Papua New Guinea.

Vietnam's long history of comparatively sophisticated nationwide forest management and technically capable personnel has made it particularly suitable for Open Foris. Vietnam has maintained a nationwide forest management system since 1990, when it first collected satellite imagery. A National Forest Inventory is mandated by law every five years, and each cycle has included a complete re-taking of high-resolution satellite imagery of the country's forest cover—currently 323,000 square kilometers, or 39 percent of the country's total size. This forest cover is divided into three classifications: protection, which allows for limited harvesting that does not impair any major forest asset such as a river; production, which includes state forest enterprises, the country's 44 land concessions, and private plantations; and special use, which includes national parks, nature reserves, and species and habitat conservation areas.

31 http://www.openforis.org/OFwiki/index.php/Main_Page.

According to Dr. Pham Manh Cuong, Deputy Director of the Department of Science, Technology and International Cooperation at VN Forest, a huge amount of data are generated by the more than 11,000 forest rangers in Vietnam, almost all of whom have mobile phones and near 100 percent nationwide signal coverage, from forest protection stations outfitted with e-mail, fax, and at least one GPS device, and from the e-mail capability of more than 600 district offices and nine Vietnam Forest Industry and Planning Institute (FAO's partner in Vietnam) sub-centers throughout the country.

Information from all of these locations is sent to Hanoi via e-mail or fax on a regular basis. All of this makes for a large amount of data that must be sorted and made useful for national-level forest managers as well as policy makers.

Dr. Pham believes the system's large amount of information flow requires carefully calibrated allocation of resources for data management and analysis activities. "We need to define what level of information is necessary," he said, explaining that the type of and amount of data shared with VN Forest in Hanoi must be "cost-effective" and must involve quality control of field reporting.

Project

"It is our mission to enable countries to work with their own data to produce information essential for decision making and reporting," said FAO's Gino Miceli, one of the founders of the Initiative, explaining that his team simply wants to improve the management of national forest agency data so that the countries can get knowledge and information from the data. Open Foris tools, Miceli explained, aim to support all phases of the inventory process, from inventory design and data collection to calculation and production of reports and maps. Training and support is provided by FAO and partners to ensure that national staff are able to perform these essential tasks with little or no outside support.

The current Open Foris software components include the following, which FAO has deliberately kept as open source in order to allow for modifications and improvements by ICT and forest experts worldwide:

- *Open Foris Collect* allows you to collect site-specific data on paper or with portable data recorders.
- *Open Foris Calc* can import the data and calculate volume, biomass, and carbon levels and can be used for mapping.
- *Open Foris Geospatial Toolkit* allows GIS/RS experts to prepare cloud-free field maps, and land use maps and to perform stratification and other tasks.

FAO is also working on a mobile data collection platform for the Android operating system in partnership with the Arbonaut company. The platform would enable the collection of tree and forest data in the field that could be easily transferred into other Open Foris programs for analysis and mapping.

FAO has been developing a mobile version of Open Foris Collect for portable field data recorders. Miceli said FAO considered existing mobile data collection platforms but found they were not flexible enough for the much more complex and varied purposes of national-level forest inventory. They wanted users to have more control of the forms and data structures. "We're making it so easy for the user to set up Collect that they don't even realize that they're designing a relational database," he explained.

The new Collect user interface will take a forms approach, but the back end will have all of the metadata, invisible to the person inputting the data. The metadata allows for greater integration across Open Foris apps and with other systems.

FAO envisions three classes of Open Foris Calc users: people who analyze and query data—such as a ministry official or whoever needs actual result data; forest scientists who can create new calculation models (for example, a new height model by which foresters could calculate a tree's height from a position on the ground); and people engaged in setting up the system and executing country-specific computations.

Solution

Open Foris tools are built precisely to provide efficiency and accuracy through flexibility and comparability, which are attributes the FAO hopes VN Forest will make full use of in Vietnam. Open Foris Collect can be configured by national staff to perform flexible data checking. This is accomplished by configuring the platform to compare different sets or types of data. It also provides a well-defined workflow, to help users manage and perform data entry and data cleansing. And after data are entered and cleaned, they are locked and may be exported to various formats (csv and xml).

Open Foris tools aim to be modular and flexible, allowing each tool to be configured and customized to country needs. This has been necessary because their systems and data needs differ greatly.

Despite the customization or data format, however, all deployments seek to exploit the clear potential of visualized information for stronger monitoring and evaluation work. Forest data that are geo-coded can be included as one of multiple layers of data in any GIS-like mapping program. Layering different types of data on a map can allow the identification of facts that would otherwise likely have been missed if the data remained in spreadsheet form. The Open Foris suite supports biophysical, governance, and socioeconomic data, allowing for layering that provides important insights into the socioeconomic ramifications of national forest policies.

New tools such as those offered by Open Foris introduce new efficiencies for national forest management and analysis. Yet they also introduce new opportunities to provide useful information to the public—information that could help the media cover the government's management of a country's forest, assist conservation efforts, and provide a way for independent scientists to conduct research.

On the other hand, while Open Foris tools give forest institutions the means to improve data collection and analysis, their use requires a significant commitment of human and budgetary resources. Field data collection itself can be quite costly due to the amount of staff hours required. These challenges highlight a potential need for technical assistance for forest agencies—not with the technology itself, but with the development of plans and processes for effectively using that technology.

Major Takeaways

Any government planning to eventually open its forest data to the public saves time and resources by choosing platforms, data formats, and systems that are best able to facilitate internal use and transparent external access. Open Foris tools allow for a smooth transition once a country like Vietnam decides to adopt an open data policy. Specifically, Open Foris Calc allows governments to release subsets of data in a controlled way.

Despite the benefits of open data, making the entirety of a country's forest information public involves several different types of vulnerabilities. If it is revealed that a particular area has less monitoring, it may become a target for illegal logging. Similarly, if inventory data reveal the location of high-value trees, it could make them targets for illicit harvesting.

Acknowledging the sensitivity of locational data, FAO has designed Open Foris with security in mind. Not only does it include certain permission levels for various management responsibilities, Open Foris apps have the capability of protecting specific forest plot location information while still releasing enough information to allow for statistically significant research. Researchers can still analyze forest data without creating opportunities for outsiders to exploit the data to the detriment of the forests.

Sources:

Gino Miceli, Forestry Information Systems Specialist, FAO.

Manh Cuong Pham, VN Forest, Vietnam.

6.3 THE WAY AHEAD—THE EFFECTIVE USE OF SATELLITE IMAGERY AND OBJECT-BASED IMAGE ANALYSIS SOFTWARE IN LAOS[32]

Properties of Featured Technology: *Custom installation, GIS, eCognition, automated, license fee, service provider* (see also annex 4).

Context

From multi-million-dollar Lidar data acquisition to GSM-enabled remote sensors to portable bar code scanners, there are many new costly devices that promise more-efficient and accurate forest management processes. Many of these tools rely upon the details and precision of high-resolution satellite imagery that itself requires a new set of options and choices for effective use. This ever-increasing diversity of choices makes it more difficult for forest agencies to conduct cost-benefit analyses on potential tool investments.

Smartphones and other mobile devices are having increasingly diverse features previously found in only dedicated high-end devices. The convergence of technologies has led to the gradual replacement of low-end GPS devices with smartphones with appropriate apps in recreational and non-commercial navigation markets. In professional forest management and law enforcement,

32 http://www.jica.go.jp/project/english/laos/006.

most of the technology applied is rugged professional-grade. However, these are often made available by donor-funded projects. Once usually budget-constrained agencies start procuring devices with their resources, it is possible that consumer market-oriented smartphones and relevant apps will gain more attraction as the budget-friendly second-best option.

In some situations an agency's information needs are so clear and the potential tools are so much the right fit that it becomes easier to set priorities for the resources that are available. One example of this is the Forest Inventory and Planning Division (FIPD) in Laos, which has found high-resolution satellite imagery[33] and object-based image analysis software very useful in its work monitoring illegal logging.

Laos is a country of 230,800 square kilometers that has long suffered from the scourge of trees unlawfully being cut and taken from its forests. According to the International Union for Conservation of Nature (IUCN), the forest cover has shrunk to 35 percent of the country's area from a figure of 71 percent in 1940. IUCN attributes part of this to illegal logging.

Challenge

Illegal logging in Laos, where the lack of road infrastructure and difficult terrain make it logistically difficult to monitor forests, mainly centers on 10–15 high-value woods such as multiple varieties of rosewood. These can fetch $1,500 per cubic meter before export and are sold for up to $5,000 per cubic meter online. The illegally harvested wood is mostly cut into rough timber and exported to Vietnam, Thailand, or China for processing into furniture that is then exported to markets in China, Russia, North America, and Europe.

Often the loggers aim to remove only the trees of certain species and sizes. If they cut down a tree and find its interior less than ideal, they often will not bother removing it from the forest. Discovering these trees is often beyond the capacity of current forest monitoring approaches, which only involve irregular on-the-ground observations by forest inspection officers. They do not conduct regular foot patrols, nor do they regularly use other technologies to assist in their monitoring. They mainly rely on the network of informants that the inspection office maintains throughout the country. The goal therefore for FIPD has been to detect the removal of individual trees on satellite images covering hundreds of thousands of square kilometers, even though they sometimes can be very difficult for the human eye or pixel-based image classification software to notice.

Solution

High-resolution color satellite imagery combined with object-based image analysis software is very well suited for this type of challenge and has proved especially useful in Laos. The Japan International Cooperation Agency–funded Forest Information Management Project, which started in 2009, supported the creation of a nationwide high-quality imagery baseline for Laos through which 5m resolution RapidEye multispectral imagery was taken of the entire country over three months. The quality imagery enabled remote identification of selective logging that was confirmed in situ by the Lao PDR's Department of Forest Inspection (DOFI) with the support of the Sustainable Forest and Rural Development Project funded by the World Bank and the government of Finland.

Aruna Technology Co., Ltd., a company based in Lao PDR and Cambodia, integrated the baseline data with newly acquired imagery and was able to identify locations of selective logging, and it even demonstrated the ability to detect the individual tree removal. According to Aruna owner Jeffrey Himel, the ability to detect cutting of individual trees visually enables development of more-automated solutions that could provide real-time monitoring of illegal logging in Laos and benchmark maps for future REDD carbon credit projects. In the future, these benchmarks will be used as baselines against which new carbon credits can be allotted.

Software

With the imagery successfully gathered, FIPD procured eCognition object-based image processing software and worked with Aruna to quickly prepare a very detailed "segmentation" of small polygons from the imagery that can then be classified into a forest and land cover map to serve as the benchmark for the whole country.

The eCognition software was developed specifically to make sense of detailed and complicated data, originally for medical imaging technology used for scanning the human body. It was initially

33 In this case study, "high" resolution refers to imagery between 2 meters and 10 meters resolution, whereas "very high resolution" or VHR imagery is less than 2 meters.

developed by a think tank founded by Gerd Binnig, who shared the 1986 Nobel Prize for physics for his work on a specialized microscope.

According to Himel, image analysis and classification previously relied on pixel-based techniques. "This involved taking the digital number values of individual pixels from the imagery and using a range of mathematical algorithms and techniques to characterize each pixel based on its similarity to others," he explained, mentioning several challenges for imagery accuracy, including atmospheric conditions and complexity of the landscape. "Object-based image classification takes a completely different approach. Rather than focus on pixels, the method groups them into regional objects based on aspects such as color, texture, tone, shape, size or context. By 'segmenting' the image into these larger objects, a more accurate analysis is enabled, then the objects can be more accurately classified."

As noted by Trimble, a provider of location based solutions, the technology is particularly useful when small or otherwise unobservable changes in the forest would otherwise remain unnoticed. According to Trimble materials, eCognition will process and layer a variety of forms of geographically accurate data, including raster images, LiDAR cloud points, GIS vectors, radar data, and hyperspectral data. The software can also extract vertical and horizontal features; integrate images of different scale, resolution, and spectral bands; and enable correcting for atmospheric-induced mistakes.

Most critically, eCognition can integrate such information as accessibility or proximity to human dwellings into the segmentation and classification. "Rather than examining individual pixels in isolation," the company says, "it distills meaning from the objects' connotations and mutual relations." On a technical level, this distillation involves the software employing fuzzy logic to determine the probabilities of values that are not binary. On a simple level, the advanced software helps answer a seemingly straightforward yet guilefully complex question: "What is happening, where?"

Policy Choices

While powerful, the software requires that forest agencies make many strategic decisions and streamline their data processing and information flows accordingly while maintaining a strong focus on quality control. The institutions require a systemic vision for data management and use; remote sensing analysis should not be thought of as simply a purchasable product. While in most cases the richer and more diverse the imagery and derived data are, the more potentially insightful the information product becomes, here achieving a quality result remains difficult and challenging. Not surprisingly, powerful software like eCognition is not simple to use. Currently it requires customizing image import and export rules for each project and adjusting settings to accommodate for different pixel sizes in the various images.

The challenge for forest agencies therefore is to have informed expectations of what insights this type of remote sensing could provide with available resources—a challenge with a chicken-and-egg dynamic: In order for them to know ahead of time whether the remote sensing is worth its cost, they essentially need to know what the analysis will reveal before they commit to pay for it. Yet if they knew the results, they wouldn't need to pay for the service.

Remaining Challenges

The frequency with which a forest agency processes satellite imagery through object-based image analysis software implies different policy approaches. The more frequent it processes the information, the more it places an evident priority on the information and the more reactive it can be. Less frequent information processing may come as a result of limited budgetary resources or a low prioritization, but it nevertheless limits monitoring ability and the potential for the information to implement any actions that could help curb illegal activities. While the discovery of some objects intended for long-term use, such as illegal logging roads, allows for longer reaction periods, infrequent image collection will only provide the un-actionable facts of what has already happened.

Himel of Aruna Technology believes most solutions will rely on a combination of lower-resolution imagery such as RapidEye in combination with field survey and higher resolution imagery. He pointed out that as resolution and frequency of resolution increase, acquisition costs can increase exponentially. The costs and logistics of the associated activities of confirming tree felling in the field, data processing, and the capacity for interdiction must also be considered.

Major Takeaways

Costly image analysis software does not make sense for all countries or situations. Other countries may have starkly different illegal logging issues than Laos, with similarly different varying potential for technology. In those cases, instead of organized and precise targeting of valuable individual trees chosen for their export value, illegal loggers usually will cut down entire stands of trees to provide local households with firewood. These clear-cuts can be seen with lower resolution imagery and are often discovered by the naked eye by forest rangers on the ground.

Any forest agency considering the use of satellite imagery in combination with object-based image analysis software has a tough set of choices to face. The skill sets involved are rare enough that they risk overburdening or losing a well-trained staff member to a higher-paying outside employer. The software and satellite imagery are not cheap. These factors often lead to the decision to outsource the service, even if such consultancy services are not cheap. At least then the cost is a "one-off" and does not present the challenge of future recurring costs.

In Lao PDR, a middle ground has been available: local technological expertise has provided the support and expertise to enable the FIPD to develop its capacity step-by-step rather than depend on outside consultants. In addition, forest agencies need to continually think through the life cycle of data collection and utilization. In essence they need to begin with the desired effect on forest governance and then work backward to initial data collection. For example, if an agency plans to collect data often, the establishment of the imagery baseline will enable lower-cost monitoring over time and will improve the accuracy of results.

Laos' experience with the software and imagery shows both the potential of the tools and the complex planning they require. It could be said that technology presents a double-edged sword because it has given the country's forest inspectors the gift of sight and yet has presented them with newly challenging policy questions. Hopefully for them, the way forward for this technology will likely involve decreasing costs, increasing user-friendliness and more-widespread and effective application.

Earth observation images and their interpretation provide only a starting point for investigations. As in the case of Laos, the information from these images needs to be translated into useful geo-referenced information for enforcement. In this case, the illegal logging sites were identified from the images and the coordinates recorded. After that, DOFI officials verified the sites with GPS-directed field visits.

With the increased capabilities and availability of highly capable cellphones, these questions have to be answered in an increasing number of cases and by an increasing number of users both inside and outside the forest profession. The Laos case demonstrates one way of working with professional-grade devices. It may also show the way for later deployment of multiuse retail devices.

Sources:

Interview with Jeffrey Himel, Aruna Technologies Owner, Vientiane, Lao PDR.

6.4 COMMUNITY-MANAGED SUSTAINABLE AGRICULTURE—A BOTTOM-UP REVOLUTION ASSISTED BY MOBILE TECHNOLOGY[34]

Properties of Featured Technology: *Java, basic phone, SaaS/Cloud, GIS, crowd-sourcing, service provider* (see also annex 4).

Context

With more than 1 million farmers in Andhra Pradesh, India, the Community-Managed Sustainable Agriculture (CMSA) program empowers members of rural communities with information and training to grow natural fertilizers and use non-pesticide farming methods to dramatically improve yields and increase farmers' incomes. CMSA deploys initiatives such as farmer field schools (FFS) to provide hands-on demonstrations, training, and extension services in over 11,000 villages. The program works with over 2,000 village trainers and community resource persons to provide training and coordination.

Due to the immense scale of operations, the CMSA project faced implementation challenges in coordinating and monitoring a large statewide program through isolated rural community professionals. Low-cost java-based mobile phones provided the opportunity to connect various field trainers and coordinators under a uniform training and data capture program, provide them a structure to carry out their work, monitor their operations, and collect data

34 http://65.19.149.140/pilots/cmsanew/ab_us/aboutus_modify.html.

regarding the impact and effectiveness of interventions as well as the major roadblocks to greater adoption of sustainable agricultural methods.

Since the adoption of the CMSA mobile application in September 2011, some 1,300 community professionals have been trained, benefiting large numbers of smallholder farmers directly. Data collected have been analyzed to capture effectiveness of alternative methods such as the System of Rice Intensification (SRI) and non-pesticide management.

For nearly a decade, the Society for Elimination of Rural Poverty (SERP)—a semi-autonomous government agency in Andhra Pradesh—has been actively promoting mobilization of the rural poor into self-help groups and connecting them to markets and last-mile services. The agency currently works in 38,550 villages and reaches 11 million households. Federated at the group level, village level, and block and district levels, one of the main goals of the organization is to build leadership capacity and facilitate demand-driven efforts to improve livelihoods through effective agriculture, livestock, dairy production, non-farm skills, financial literacy, and health and nutritional awareness, among others.

SERP initiated CMSA in 2004 in order to address the major causes of agriculture distress: extensive use of chemical inputs, high costs of agriculture, displacement of local knowledge, unsustainable agricultural practices, and lack of market access. CMSA supports poor farmers in adopting sustainable agriculture practices, to reduce the cost of cultivation and increase net incomes by moving from input-centric model to a knowledge- and skill-based model. The program is therefore focused on knowledge transfer, capacity building, and empowering farmers and community resource professionals in order to promote cost-saving, yield-boosting, sustainable agricultural practices.

Mobile Application

The goal of the CMSA mobile application is twofold. On the front end, it seeks to help community resource professionals organize their time and operations each day by providing a structure for carrying out operations and an incentive to capture data regarding work completed, along with a method to follow progress.

In the back end, the monitoring and evaluation platform helps collate and analyze collected data to monitor operations real-time and evaluate effectiveness and impact of interventions over time. Information is also relayed in real-time on a public website to maintain transparency and accountability of field operations both within and outside the implementing agency.[35]

The CMSA mobile application is designed by Bluefrog, a technology service provider based in Andhra Pradesh. The application is built in J2ME to accommodate basic feature phones. Data received are hosted in the service provider's server, through software as a service model.

The various menus of the application are meant to capture different initiatives in the CMSA program for which each trainer is responsible. In general, trainers are responsible for running programs in five different villages five days a week, starting farmer field schools, inspecting non-negotiable flagship components, inspecting botanical fertilizer shops, and attending community group meetings to run extension video service—Digital Green—to promote further awareness of methods and adoption.

The following is a description of some of the components covered under the mobile application.

Field-based Extension Program—Farmer Field Schools: Farmer field schools are field-based activities for groups of farmers to engage with best practices. The FFS menu in the mobile application enables the user to capture the attendance of the farmers, the image of the group, and the image of the land where the meeting has been held for different parts of the discussion. This enables the project to capture the adoption of CMSA practices in various geographic areas.

*Ultra-poor[36] Plot Program—36*36:* Intended to address the nutritional needs of the poorest of the poor households, the 36ft*36ft model proposes a diverse range of crops—from fruits and tubers to vegetables and pulses—to promote nutritional security and year-round income. The mobile application allows field coordinators to capture data from farmers experimenting with this seven-tier cropping model and to track the income generated from each crop and the expenses incurred.

35 http://65.19.149.140/pilots/cs/dashboard.aspx.

36 Ultra-poor is a term used to describe the poorest of the poor in India.

System of Rice Intensification Methods: This revolutionary method of rice cultivation is intended to be cost-effective and resource-efficient for the most popular crops produced in Andhra Pradesh—paddy. Under this method, a minimum amount of water is used instead of continuous flooding, and seedlings are replanted with more room for root growth, producing a greater crop yield. The mobile application enables manual entry of the enumerator to capture the amount spent on agricultural inputs for this method, the yield, and income from the crop. This is meant to ensure that there is adherence to SRI methods and that the methods are effective in producing desired effects on income. Cross-validation potential in this system is quite limited.

Adherence to "Non-negotiables": In order to capture the level of adherence to sustainable practices, community enumerators record data on the methods followed by the farmer. These include community bonfires, seed treatment, bird perches, border crops, trap crops, yellow and white plates, intercrops, light traps, pheromone traps, delta traps in ground nut, alleys in paddy, cutting of the tips in paddy crops at the time of transplantation, and application of botanical extracts as needed. This is meant to enable the project to understand adherence to methods by individual farmers in relation to their yields, as well as horizontal adoption to various methods by region. While the system provides an overall picture of adoption, individual adherence measures are not cross-validated through the application.

Service Features

Incentives for Excellence: The service features of the CMSA mobile application strive to obtain quality and complete information by incentivizing frontline staff. The honorarium received by these community workers to compensate for wage loss is Rs 4,000 (~$80) per month. For those who receive 91–99 percent performance grades in data submission, a Rs 1,500 bonus is offered. Those who submit complete data receive a substantial Rs 3,000 bonus on top of their honorarium. The project also offers bi-monthly refresher training, where staff can improve their data entry skills, and basic troubleshooting. Rewards for top performance, combined with continuous technology training, rather than a daily incentive for submission, incentivizes frontline trainers to improve their performance. So far, approximately 200 of 1,300 staff receive the monthly bonus, with about 10–20 receiving the 100 percent grade.

Promoting Sustainability: In addition to training thousands of community professionals in collecting information, and using it in turn to structure their work, the project also coordinates with five elected members for district subcommittees to take over coordination 10 days a month—6 days in the field, 2 days at district-level meetings on staff activities, and 2 days in the main office at the state level. These activities allow members within community institutions (federated self-help groups) to begin sharing in operational duties, and eventually taking ownership of the project in the future.

The tool has effectively helped in the following:

Overseeing Operations. CMSA is a knowledge-intensive, farmer-centric program where individuals must relearn new methods to protect their crops from bad pests and learn to encourage beneficial worms and other insects and natural process to rejuvenate the soil. Due to its knowledge-intensive nature, much training is required before farmers can successfully transfer to non-pesticide farming systems. Therefore the mobile application has a strong focus on structuring ongoing training activities with farmers to grow natural fertilizers and adopt non-pesticide farming practices.

Quantifying Impact. By capturing attendance and participation in individual programs by farmers, the CMSA program is building the ability to understand changes in yields, artificial input use, adherence to different programs, and the impact on overall income and well-being. This type of rich data on a large scale allows impact evaluation at a randomized scale to test the effectiveness of various interventions.

Evaluating Effectiveness of Intervention. Sustainable methods that avoid chemical fertilizers and pesticides involve a paradigm shift from input-centric agriculture to a knowledge-based model. This entails considerable risk for the majority of farmers, whose crop may be their only source of income each growing season. Observation of crop-cutting experiments, captured through mobile phones, allows the systematic collection of data on the impact of these sustainable methods on farmer income (lowered costs, increased outputs), providing proof of concept for farmers and promoting broader adoption of these methods.

6.5 THWARTING DROUGHT—MOBILE-BASED DATA COLLECTION FOR DROUGHT PREPAREDNESS IN UGANDA[37]

Properties of Featured Technology: *Java, basic phone, smartphone, hosted, frontline workers, open source* (see also annex 4).

Context

As part of a regional initiative to reduce the risk of drought in East Africa with Early Warning Systems, community chiefs in 55 village centers are collecting specific and tangible data in resource availability and behavior to identify indicative patterns among the rural pastoral communities of the Karamoja region.

Located in the arid northeast of Uganda, Karamoja has the lowest human development indicators of any region in the country.[38] The region suffers from chronic poverty, malnutrition, and food shortages, as well as frequent droughts, due to generally poorly distributed, unreliable, and low rainfall amounts. Unlike other regions in Uganda, which have a bimodal rainfall pattern, Karamoja's pattern of rainfall allows for only one planting season, and the unpredictability of this pattern further exacerbates agricultural livelihoods. Given heavy reliance on cattle, sheep, goats, and poultry in the pastoral and agropastoral communities as food, investment, and safety net, tracking vulnerability to drought requires indicators such as water availability, agriculture, and livestock conditions so that communities may efficiently make the best of the land's low primary productivity.

Project

In an attempt to tackle the challenges of delays in data collection for preparedness and relief in vulnerable drought-prone regions, FAO and the Agency for Technical Cooperation and Development (ACTED), in partnership with a local district government in Uganda and inspired by the Kenyan Drought EWS, created a mobile application that enabled early signals to be collected and collated instantly online and fed into an early warning algorithm. The prior delay in manually collecting, aggregating, digitizing, and analyzing data had severely delayed information transmission and thereby rendered the early warning system ineffective. The new early warning algorithm was used to generate a drought bulletin used throughout the district for drought preparation and relief efforts in the Karamoja region of Uganda.

When the Drought Early Warning System (DEWS) was first introduced, parish chiefs conducted the survey by hand, noting the information on paper, which was then delivered from the sentinel to the subcounty chief, and then to the DEWS Focal Person. It was entered manually into the system and then analyzed and disseminated in the form of drought bulletins, delaying the process by five to seven business days. A year and half into the project, the impact of the delay of paper-based data collection was evident—forecasts and predictions were less relevant than before. With the emergence of greater network connectivity and affordable mobile devices, ACTED saw an opportunity to bring mobile-based data collection to the DEWS project.

The mobile-based data collection project to inform monthly drought bulletins is the result of a partnership between three groups: local government partners who collect the information monthly through their area chiefs at 55 parishes (village clusters) and publish the monthly bulletin; ACTED, the international NGO that was able to bring together best practices and the stakeholders to develop the Early Warning System for Karamoja; and FAO, which was able to design and work with the technical team to develop the mobile application using Nokia Data Gathering and which provided operational and trouble-shooting capacity training to the project.

The Drought Early Warning System used in Karamoja relies on monthly weather forecasts from the Department of Meteorology of the Ministry of Water and Environment. The vulnerability indicators are collected from households, kraals, and markets by the village chiefs.

In order to obtain the information in a timely manner and to support communities and organizations in preparing for drought, three main factors played a key role: designing the optimal data collection parameters, a symbiotic partnership that enabled community ownership, and accessible mobile technology with network connectivity.

37 http://www.acted.org/en/uganda.

38 The administrative area in Karamoja has seven districts, which are further divided into subdistricts and then into parishes. Parish chiefs are selected by the local government and are responsible for a number of duties. Parishes have a market, where crops are sold, and kraals, where livestock are traded.

Designing the survey was a collective effort between stakeholders to arrive at a comprehensive yet efficient set of questions that can be administered through a basic feature phone:

- *Household survey (October 2012):* Collects data from the same 10 households in each survey location every month, including type of water source and time spent to fetch water from each, quantity of water fetched, security, type and source of food, crop conditions and type of crops, and alternative livelihood indicators such as price of casual labor.
- *Kraal survey:* Tracks the same five herds of cows of about 20 animals each, monitoring livestock body condition and access to grazing areas.
- *Market survey:* Administered monthly, tracking type and number of animals available in the market and market prices for the main sources of grain, meat, and energy.

Once collected and uploaded in a location with adequate connectivity, the data are processed on a Nokia server and exported in CSV format and imported to the DEWS database through a conversion applet. The DEWS is a web-based centralized application, on a server hosted by the Ministry of Agriculture, Animal Industries and Fisheries of Uganda. As the FAO involvement in the project ends in 2013, an integrated solution between Nokia data gathering technology and DEWS is currently being planned. The project is also developing new web-based products to further information dissemination.

The parish chiefs are selected to be enumerators based on motivation, accessibility, level of literacy, and availability of kraal and market in their parish. Employed by the local government, they are nominated by subcounty chiefs to be DEWS data collectors, enabling the government to run data collection sustainably beyond the funded project period.

Despite the fact that no additional compensation was offered, enumerators who were nominated were eager to participate because of the additional training, phone use, and the connections that the project offered. Working in isolated project areas, the periodic training brings together various parish chiefs to discuss challenges in getting information and collecting data, and provides access to a network of similar community leaders.

Prior to technology training, the FAO trainers conducted sensitization to teach the interview process first. When enumerators are aware of how the data will be used, and why it is important to have accurate numbers, they are able to better establish a relationship with an interviewee, especially when disclosing potentially sensitive household information. Because enumerators are usually already familiar with texting on mobile keypads, only a half-day of initial technology training was required prior to implementation.

Main Takeaways

Empowerment of communities and local implementers: Periodic user training and capacity building generates greater awareness of digital tools and ownership of the process.

Symbiotic partnerships can combine resources with capabilities: FAO brought in technical knowledge and training, and ACTED provided implementation capacity in coordination with local communities and government.

Increased timeliness of early warning: Real-time data collection and drought bulletin production increase the timeliness of drought warning and the preparation response put in place by communities and partners.

Decrease in costs leads to greater likelihood of sustainability: As transport costs for carrying questionnaires from the field to sub-country and district offices is eliminated, data collection becomes more efficient and more viable for government adoption.

Sources:

Phillip Fong, FAO, interviews on 13 February 2013 and 20 March 2013.

Malika OGWANG, ACTED, interview and survey documents shared on 20 February 2013.

K. Gelsdorf, D. Maxwell, and D. Mazurana, "Livelihoods, Basic Services and Social Protection in Northern Uganda and Karamoja," Working Paper 4 (London: DFID, 2012).

E. Stites, L. Fries, and D. Akabwai, "Foraging and Fighting: Community Perspectives on Natural Resources and Conflict in Southern Karamoja" (Medford, MA: Feinstein International Center, 2010).

Chapter 7: CONCLUSION

There has been extensive expansion in the number of ICT4D products and services available in recent years, along with substantial digital experimentation at all stages of the monitoring and evaluation process in agriculture and forest sectors. As these experiments have matured into scaled projects, evidence of their efficiency is being observed. Accrued knowledge on using ICT specifically in data collection and data management is increasing the capacity of organizations and governments to incorporate technology into their projects and programs more effectively.

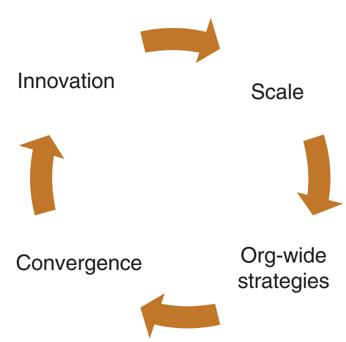
Yet despite the growth in active use of ICT in agriculture and forest projects, the technology still remains a latent consideration in many rural development projects. Confusion on how to properly use mobile applications and other digital tools remains fairly widespread. Like boarding a moving train, the constantly evolving and fast-paced ICT sector appears difficult to carefully, slowly, and thoughtfully engage in. Yet this should not discourage practitioners' use of ICT. Strategies to effectively think about and incorporate these technologies are emerging. This operational report is one attempt to aid practitioners in that decision-making process.

In summary, technology itself is not an end but a means. The specific project and people needs may or may not be a good fit for the use of ICT. If this technology is deemed suitable to achieve data collection and M&E goals, implementation models that maximize efficiency—such as the use of frontline workers or automated capture—can be considered and systems designed. Only then should specific features of technology be deliberated. And as in any other public goods project, service design must be carefully considered. Hiring analysts who can perform quality data analysis, incentivizing adoption, and managing risks appear to be some of the most important tasks when deploying ICT.

Finally, with increases in the effective use of information and communication technology, macro-level phenomena are being observed. (See figure 7.1.) As more and more projects tap into ICT for data collection and M&E, large agencies are choosing to develop organization-wide strategies that lay out ICT policies, best practices, and interoperable access. This has led to increased convergence around the most effective technologies, mobile applications, and ecosystem strategies. The sector is reaching a plateau, making it easier for non-technologists to grasp and use ICT in many of their projects.

However, new frontiers will continue to emerge as convergence inspires innovation and improved solutions to new challenges. To prepare for these new frontiers, projects in agriculture and forests

FIGURE 7.1: Macro-level Effects of ICT in Data Collection and M&E



should remain nimble and use technologies that can easily transfer data from one platform or provider to the next. Feedback loops between operations, staff, managers, policy makers, and users should help to clarify when it is time to "update" ICT approaches. Most importantly, practitioners should not wait for further convergence of agreement on technology before using ICT in their projects, as the widespread and continued use of ICT is what leads to that. Rather, practitioners should engage with ICT as often as it meets project needs and contributes to goals associated with improving rural livelihoods and achieving climate-smart landscapes. Using this guiding report and other operational tools should provide ample assistance in reaching those goals.

Annex 1: LIST OF TOOLS MENTIONED IN THE REPORT

Cropster	www.cropster.org
DataWinners	www.datawinners.com
doForms	www.doforms.com
EpiCollect	www.epicollect.net
Magpi	www.magpi.com
Esoko	www.esoko.com
ESRI	www.esri.com
Freedom Fone	www.freedomfone.org
FrontlineSMS	www.frontlinesms.com
iFormBuilder	www.iformbuilder.com
Kimetrica	www.kimetrica.org
mKrishi	www.tcs.com/offerings/technology-products/mKRISHI/Pages/default.aspx
Mobenzi Researcher	www.mobenzi.com/researcher
Nokia Data Gathering	nokiadatagathering.net
Open Data Kit	opendatakit.org
OpenXData	www.openxdata.org
Poimapper	www.poimapper.com
TechnoBrain	www.technobraingroup.com/products/techno-brain-project-monitoring-evaluation-system.aspx
Text to Change	www.texttochange.org
Grameen	www.grameenfoundation.org
Sensemaker	www.sensemaker-suite.com/smsite
CognitiveEdge	cognitive-edge.com
TotoAgriculture	www.totoagriculture.org
PROFOR	www.profor.info
Connect Online Connect Offline (COCO)	www.digitalgreen.org
ArcGIS	www.esri.com/software/arcgis
Google Earth	earth.google.com
Bing Maps	www.bing.com/maps
STATA	www.stata.com
SPSS	www.ibm.com/software/analytics/spss/
StatTransfer	www.stattransfer.com
Formhub	formhub.org
OpenForis	www.fao.org/forestry/fma/openforis/en/
NetHope Solutions Center	http://solutionscenter.nethope.org
Humanitarian Nomad Online Selection Tool	humanitarian-nomad.org/online-selection-tool/

Annex 2: OVERVIEW OF TOOL CAPABILITIES AND CONSIDERATIONS TO ADDRESS IN A TOOL SELECTION PROCESS

In addition to general questions, a more detailed checklist is available, indicating possible variables and attributes that should be considered when selecting or preparing tender documentation for a proper toolset for projects use.

Mobile features	• offline/online capability • one-way or two-way sync (upload or also download of data) • form/survey updates
Data and user management features	• user roles • user groups • hierarchy of groups • access right features • backups • restore
GIS features	• coordinates • routes • areas • location hierarchies • use of map service providers • interfaces to GIS systems • map-based visualization features
Data reporting and visualization	• integral part of the solution • relies on external software
Exporting and importing interfaces	• MDML, Excel, Word, CSV, Tab delimited, ODBC, Text custom, SOAP, XML, API provided, Custom Interface, ESRI Shapefile, Google Fusion, HTML , JPG, KML, GeoRSS, JSON, SQL, PDF, TXT, PNG, RTF, Open Office, Google Docs, MS Access, MDML, SPSS
Security	• in-device data encryption • database encryption • data transmission encryption • access control mechanisms
Costs	• training • support • development • license • maintenance • subscription
Business model	• open source with consulting • license fee • user-based subscriptions • transaction-based subscriptions
Language support	• in device for forms (single or multilanguage switch) • in device for application • website

Data content and modeling capabilities (form features)	• text, images, single/multichoice questions, conditional subquestions, static and dynamic number of subforms, static and dynamic tables, location hierarchies, GPS, image, audio, video, numeric calculations, validation lists, validation ranges, calculated ranges, logic expressions for conditional questions, dates, time, etc.
Supported platforms and hardware	• supported server databases • supported operating systems • supported devices and device operating systems
Delivery options	• custom installations • hosted • SaaS/cloud • remote management capabilities
Provided services	• provided training, support and customization services and their geographic coverage
Performance	• complexity of forms • number of forms stored in device • number of forms stored on the server • number of concurrent users • response times • performance monitoring solutions in use • load balancing solution
Reliability	• formalized test and release processes • release notes • fail-over/redundancy solution

Annex 3: FULL LIFE-CYCLE COSTS ESTIMATION TEMPLATE

For costs comparison, a more detailed structured template can be used for determining the projected full life-cycle cost of the product set to be procured.

Hardware costs

	UPFRONT		RECURRING OVER PROJECT LIFE SPAN		
	PROCUREMENT	WARRANTY	HOSTING	MAINTENANCE	REPLACEMENT
Data collection					
Storage					
Analysis					

Software costs

	UPFRONT		RECURRING OVER PROJECT LIFE SPAN		
	SETUP	USAGE	USAGE	MAINTENANCE	SUPPORT
Data collection					
Storage					
Analysis/Visualization					

Other costs (mostly recurring)

Communication cost: Cellular Data/SMS	
Communication cost: Field-Office	
Training cost	
In-House IT labor cost	
Transportation and paper storage cost	
Labor cost for data collection	
Labor cost for data entry	
Labor for data cleansing	

Annex 4: TECHNOLOGY FEATURES OF CASE STUDIES

Shading indicates features included in the case study.

CASE STUDY 1: TIST

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Proprietary	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

CASE STUDY 2: FAO Open Foris

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Custom SW	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

CASE STUDY 3: Satellite Imagery in Laos

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Custom SW	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

CASE STUDY 4: Community-Managed Sustainable Agriculture

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Custom SW	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

CASE STUDY 5: Mobile-Based Data Collection in Uganda

Device platform	Android	iOS	Java	Palm
Device type	Tablet	Smart Phone	Basic Phone	PDA
Device capability	Camera	GPS	Signature	External GPS
Storage/stakeholder access	Custom installation	Hosted	SaaS/Cloud	Remote management
Analysis	GIS	SPSS	eCognition	Custom
Implementation model	Frontline workers	Crowd-sourcing	Passive	Automated
Business model	Open source	Custom SW	License fee	Subscriptions
Support	In-house	Outsourced	Service provider	Other
Mobile features	Online	Offline	Two-way sync	SMS
Data security	In-device encryption	Database encryption	Encrypted connectivity	Access control mechanisms

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