Research Article

Digital Green: Participatory Video and Mediated Instruction for Agricultural Extension

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Abstract

Digital Green is a research project that seeks to disseminate targeted agricultural information to small and marginal farmers in India using digital video. The unique components of Digital Green are: (1) a participatory process for content production; (2) a locally generated digital video database; (3) a human-mediated instruction model for dissemination and training; and (4) regimented sequencing to initiate new communities. Unlike some systems that expect information or communication technology alone to deliver useful knowledge to marginal farmers, Digital Green works with existing, people-based extension systems and aims to amplify their effectiveness. While video provides a point of focus, it is people and social dynamics that ultimately make Digital Green work. Local social networks are tapped to connect farmers with experts, the thrill of appearing "on TV" motivates farmers, and homophily is exploited to minimize the distance between teacher and learner. In a 13-month trial involving 16 villages (eight control and eight experimental villages balanced for parameters such as size and mix of crops) and a total of 1,470 households, Digital Green increased the adoption of certain agriculture practices seven-fold over a classic Training and Visit-based (T&V) extension approach. On a cost-per-adoption basis, Digital Green was shown to be 10 times more effective per dollar spent than a classical extension system. Investments included performance-based honoraria for local facilitators, a shared TV and DVD player in each village, and one digital camcorder and PC shared across the project area. The results are preliminary, but promising.

I. Introduction

India, like most other developing nations, is still primarily an agricultural country. More than 60% of the population relies on agriculture as a means of livelihood. Though a generational vocation, farmers have difficulty sustaining a living for their families due to social, economic, and environmental change [1]. The National Sample Survey Organization's 2005 Situation Assessment Survey of Indian Farmers studied the sources of new technologies and farming practices that farmers accessed in the preceding year [2] and showed that increasing debt and declining returns have led some to make desperate choices that include selling their land below market rates and sometimes even taking their own lives. One of the major problems lies in poor knowledge about farming itself. Farmers tend to find refuge in their own intuition and the hearsay of fellow villagers, which can result in a downward spiral of poor decision-making [3].

There are at least two dominant modes of addressing this gap in knowledge. Television and radio broadcast programs are commonly used to disseminate agricultural information across large geographies, but the information can be too general for practical use. The other alternative is agriculture extension in which trained extension agents attempt to impart farming practices and techniques to farmers through individual interaction.

Robert Evenson describes agriculture extension efforts as following an awareness-knowledge-adoption-productivity (AKAP) sequence [4]. Guiding a farmer through this progression to inculcate a particular technique is the aim of extension services. Agriculture extension in developing countries spans a history from the services provided to export-oriented crop estates during the colonial era to productivity-focused strategies, such as the World Bank's US$3 billion Training and Visit (T&V) system [5] that promoted Asia's Green Revolution in the 1970s. Today, extension remains the focus of many government programs; India, for example, has the second largest number of extension workers—more than 100,000—in the world.

The scale of actual impact, however, is confounded by logistical and resource challenges that include the sheer number of households assigned to a single extension officer, as well as the difficulty that individual officers have in establishing rapport with their potential clients [6] [7]. Extension officers tend to restrict their contacts to the richer, larger-scale farmers in each village, as they are typically the most willing to experiment with new inputs. Extension systems aim to use these farmers as models, but the field staff is rarely able to showcase the progression of these farmers to wider audiences due to social and resource limitations.

A variation of the individual-based approach is the acclaimed Farmer Field Schools (FFS) model [8] that enables farmers to improve their decision-making capacities through weekly "informal schools" in which a small group of farmers observes and evaluates possible agricultural interventions on one individual's farm. The FFS model is claimed to have spread the adoption of integrated pest management practices in Asia by graduating more than four million farmers in 50 developing countries [9]. The evidence suggests that the social value of the informal schools contributes greatly to the success of this model, although there are lingering questions about its fiscal viability [10].

It is in this context that we present Digital Green (DG), a technology-supported means of agriculture extension. Inspired by a project called *Digital StudyHall* that seeks to improve primary school education in rural India [11], we use video as a basis for disseminating agricultural practices. The components of Digital Green are: (1) a participatory process for content production; (2) a locally generated digital video database; (3) a human-mediated instruction model for dissemination and training; and (4) regimented sequencing to initiate new communities. Each of these components is discussed in detail in Section IV.

The use of video for agriculture extension is by no means new, and DG was inspired by a number of different projects. These can be broadly categorized as IT for agricultural development, video in agriculture extension, and mediated instruction for effective training with video (related work is discussed in a later section). DG weaves together the best of these three strands of work into a novel system that maximizes the impact of agriculture extension workers. Among its unique strengths, the DG system uses cost-realistic technologies, like TVs and DVD players, to build the capacities of farmers so they will be able to better manage their agricultural operations. The video-based content improves the diffusion of better farming practices and reduces the expert support required for each farmer. The videos are also localized to a region and feature the participation of familiar farmers as opposed to experts in idealized conditions.

The more critical aspects of the DG system are how video is used, and how it capitalizes on natural social dynamics to amplify a single extension worker's ability to evangelize agricultural practices. Village-level mediators facilitate the showing of these videos to ensure that farmers personally connect with the content on a regular, accessible basis.

We discuss the methodology we used to arrive at the overall Digital Green system in the following section. Later sections present our findings and results from a preliminary, controlled experiment.

II. Methodology

The work presented in this paper occurred in two stages that follow the methodological traditions of,

Table 1. Preliminary Design Experiments.

"Experiment"	"Receptiveness"
Video Producer	
low-skill facilitator	+
medium-skill facilitator	+
expert-skill facilitator	+/−
no facilitator	−
no farmer	−
Video Themes	
innovations	+
demonstrations	+
testimonials	+
concepts	+
mistakes	+
new farmers	+
showcases	+
entertainment	+
meteorology	+
cost-benefit analysis	+
entrepreneurship	+
lectures	−
events	−
Screening Location	
patio	+
street	+
school	+/−
political leader	+/−
personal TV	+/−
cable	+/−
Screening Mediator	
hand-out supplies	+
low-skill mediator	+
medium-skill mediator	+
expert-skill mediator	+/−
no mediator	−

Notes: The symbols (+) and (−) denote an initial estimation of future potential of an approach, based on the qualitatively assessed responses of farmers. Both symbols (+/−) denote a qualitative uncertainty in the utility of an approach.

respectively, contextual design and randomized control trials.

In the first stage, a human-centered and contextual design approach [12] was used for the preliminary research and design of what would evolve to become Digital Green. Through a combination of ethnographic investigation of existing agriculture extension practices, together with the prototyping of both technology and its use in a village context, we gradually acquired both a better understanding of the problems of classical agriculture extension and of the challenges to using video as a medium in rural areas.

The first author spent more than 200 days in the field within a span of one year working with GREEN Foundation, a non-governmental organization (NGO) headquartered in Bangalore, India. GREEN Foundation works in 100 rural villages in Karnataka and encourages low-external input sustainable agriculture practices, and the establishment of community seed banks to preserve the genetic diversity of indigenous crop species. For the purposes of the work presented in this article, it is important to note that GREEN Foundation's methods are based on the classical Training and Visit approach to agriculture extension in which the NGO's extension agents travel to villages and visit individual farmers to disseminate knowledge. During the first phase, we observed agents performing their regular extension duties and recorded their interactions with farmers. In addition, we experimented with producing various types of video content and also tested alternative approaches to screening and mediating the distribution of the videos, based on initial guesswork, trial-and-error, and feedback from extension staff and farmers. Table 1 briefly summarizes these experiments.

In the second stage, we fixed a particular version of the Digital Green extension model (described in Section IV) and conducted a 13-month balanced controlled study [13] in 16 villages to compare farmers' field adoptions of new practices between two forms of agricultural extension: (1) the classical extension methodology in which the NGO's extension agents performed periodic field visits and training; and (2) the regular production and dissemination of Digital Green videos mediated by locally hired village facilitators. Section V describes the methodology and results of the second-stage experiment.

III. Stage 1: Early Experimentation

Between September and March 2007, we spent most of the time observing, learning, and prototyping different techniques for applying video to ex-

tension. The experiments were conducted in two villages, comprising 375 households. The discussion in this section reviews some of the initial findings that led to the design of the components of the current Digital Green system.

To bootstrap the initial studies, the first author recorded a number of videos that featured experts, NGO staff, and farmers. The experts and NGO staff conveyed some practice to the farmers, usually with the farmers actively trying out a given technique. Other farmers were then shown these videos in various situations in their villages. We experimented with a range of possibilities in terms of how the videos were recorded and screened. Some of the parameters included:

- **Degree of mediation:** Acts of mediation include the mediator pausing the video to make additional commentary, inviting questions, or engaging in a discussion with the viewers. The degree of mediation ranged from straight playback with no mediation to highly interactive sessions with heavy mediation.
- **Background of the mediator screening the video:** Other farmers, extension officers, and PhD experts.
- **Background of people featured in video:** regular farmers, low-skill extension agents, and agriculture university graduates.
- **Type of content:** Shown under "Video Themes" in Table 1.
- **Location of screening and method of dissemination:** Shown under "Screening Location" in Table 1.
- **Other factors:** The use of extra incentives such as handouts offered during screenings, etc.

Our initial findings are described in the remainder of this section, and Table 1 coarsely tabulates our findings.

One of the clearest things we observed was the degree to which farmers sought videos featuring people similar to themselves, who spoke in their dialect and accent, and who had low- to medium-levels of formal agricultural expertise. They made snap judgments of a person's occupation, education, and station, apparently based on language, clothing, and mannerism cues, consistent with previous observations [14]. For example, a progressive farmer might be considered low-skill, an extension agent with some bachelor's-level education might be considered medium-skill, and a director-level extension agent with a master's or doctoral degree in agriculture could be considered high-skill. As Table 1 suggests, low- and medium-skilled people were generally more trusted. Interviews with farmers revealed that they had encountered many experts in the past, but that expert advice was confounding. Farmers thus expressed apathy toward expert lectures, preferring the persuasion of familiar neighbors.

Not surprisingly, farmers' interest in watching a particular video depended strongly on its content. Videos of classroom-style lectures and large events were perceived to be monotonous, and farmers themselves often requested a variety of more intimate content types that included concrete demonstrations, testimonials, entertainment, etc. In some cases, they demanded videos that featured multiple farmers adopting the same practice, possibly to see proof of a broader base of acceptance.

Farmers were always sensitive to the appropriateness of the content to the current season and the tangible benefits that its application could provide. The videos captured the range of sustainable agricultural practices that were promoted by GREEN Foundation and included demonstrations for setting up low-cost, vermicompost production units and the method of system of rice intensification (SRI). The most significant complaints about content were that a given video was not appropriate for the season or for a particular village. Farmers were not willing to sit through videos that were not of immediate value to them. A related issue was that farmers needed some assurance of immediate gains before they would be willing to consider practices that offered longer-term returns. Most of the sustainable agricultural practices that GREEN Foundation promotes can take farmers several months to realize any improvements; videos containing this content were not well-received until farmers first tried a technique with a shorter reward cycle.

The presence of the mediator during screening was also significant. In particular, a playback of video alone, no matter the content, frequently resulted in audiences leaving well before the playback was finished. In contrast, even slight mediation appeared to result in more prolonged interest. Shared TV and DVD player screenings were typically well-attended in public locations, but semi-private places,

such as a school at the edge of a village or the house of a partisan politician, restricted farmers' participation. Exchanging DVDs with individual households or broadcasting the videos on local cable networks allowed the videos to be seen by some farmers who were otherwise unaware or incapable of attending public screenings; however, without the involvement of a human mediator, these methods tend to connect with only the most progressive farmers. A similar response was observed when a shared TV and DVD player was set up in a public location without the presence of a mediator. In all cases, there was some initial curiosity, but interest was rarely sustained without a mediator.

Farmers were more eager to participate if the tools or ingredients needed to adopt a technique were provided during the screenings. Even if this equipment was provided for a fee, farmers preferred to make their purchases at the screening rather than journey to a larger village or town on their own. For example, during one particular screening, 16 farmers were introduced to a low-cost method of cultivating *azolla,* an aquatic fern that can be used to add nutrients to animal feed and to fix nitrogen for paddy. Twelve of the farmers expressed interest in the practice and were given plastic sheets and cultures to attempt the method on their own. The remaining four claimed the technique was either not applicable or not understandable to them.

Farmers frequently required more than a single session of video to absorb the material. During the screening of the *azolla* video, for instance, the mediator repeated the content to allow individual farmers in the audience to demonstrate that they could recall both the required set of ingredients and the necessary steps to construct a cultivation unit. To mitigate the complexities of the promoted practices, GREEN Foundation segmented each practice into time- and event-based modules. These modules were used to develop the various field demonstrations and exposure programs that the NGO conducted. For the cultivation of transplanted paddy, the NGO developed modules for varietal selection, seed bed preparation, seed treatment, planting method, field preparation, manures and fertilizers, water management, pest and disease management, post-harvest processing, and marketing. These modules provided the basis for producing videos in the field.

Though the information was sectioned into modules, farmers still requested that the same content be shown multiple times to build sufficient confidence before they attempted a procedure on their own. In some cases, an extension agent's direct support was required for adoption. Going back to the example of screening a video on *azolla* cultivation, of the 12 interested farmers, only three successfully completed the process without any field support. Another three farmers began the process on their own, but requested a follow-up visit to validate their work. The remaining six farmers required the full-time supervision of extension staff.

After about six months, our key findings were: mediation is essential to the process of extension; farmers were most convinced by appropriately targeted and pitched content; and concrete, short-term incentives are critical in the beginning. We began to believe that we were converging on a video-based system that could amplify the effectiveness of extension workers.

IV. The Digital Green System

The Digital Green system (DG) was designed based on the preliminary design experiments described above. DG consists of (1) a participatory process for content production, (2) a locally generated digital video database, (3) a human-mediated instruction model for dissemination and training, and (4) regimented sequencing to initiate new communities.

A. Participatory Content Production

The DG cycle begins with producing video content. Although we encourage the recording of a number of different types of content, including testimonials and what might be considered entertainment (e.g., groups of village children singing), the majority of the video produced is instructional in nature. Instructional videos are recordings of demonstrations that are made when an extension agent is teaching a farmer a new technique. Typically, the videos prominently feature either an experienced farmer showcasing the benefits of a particular technique, or a new farmer attempting a technique on her field for the first time. As seen in Figure 1, most video recordings involve three people: a teacher, a farmer, and a content producer who doubles as the camera operator.

The content producer tries to enforce the following format in each instructional video: (a) a brief verbal overview of the process; (b) an itemization of

Figure 1. An extension officer prepares to record a demonstration for setting up a low-cost, vermicompost unit, featuring local farmers in Bhanavasi, Karnataka.

the required resources and associated costs; (c) step-by-step instructions in the field, usually with the farmer and, sometimes, also the teacher actually implementing the technique; (d) a showcasing of the uses and benefits; and (e) interactions with farmers to address common questions and concerns. Some advance "lesson planning" in the form of informal storyboarding is encouraged for content producers so that they are prepared for recording, but much of the actual recording in the field is, at once, ad hoc and chronologically true to the way extension agents interact with farmers.

Content producers can be university scientists, NGO experts, field staff, progressive farmers, and other volunteers from the local community, with the most common producers of content being NGO extension agents. Extension agents perform their regular extension duties, mostly field assessments or demonstrations, and capture these interactions with farmers on video. In this way, an extension agent can produce one or two clippings per field visit with minimal additional effort.

One of the crucial aspects of DG is the inclusion of local farmers in the instructional videos. This is a critical, but subtle feature, based on our learning that other farmers in the area are more likely to adopt a practice when they can see that is already being implemented by their peers. As an added benefit, the appeal of appearing in a video is incentive enough for some farmers to adopt a new practice. Occasionally, farmers themselves also contribute insight or innovative techniques during recordings. However, we should not over-romanticize this possibility—in the majority of cases, the expertise does lie, in fact, with the extension agent, and the primary value of the farmer's participation is to demonstrate willingness to learn.

The NGO's extension agents are already attuned to the needs and local variations in what information should be provided to the farmer, so by hitching the recording process to an existing extension system, appropriate content is naturally generated.

The videos are made using inexpensive camcorders; external microphones and tripods help to improve the quality of the audio and video production.

B. Locally Generated Video Database

Content recorded in the field, like all raw footage, is usually unusable as is, so DG requires at least one video editor. This person must demonstrate basic computer literacy, have some rudimentary understanding of the nature of the content, and be capable of being trained in the basics of video post-production. In our case, we found this role is best filled by someone with at least a bachelor's degree who has discipline and experience with formal training and critical thinking.

Video editors serve as the second and final checkpoint at which the recommended format of instruction video is ensured. Editors check for the accuracy, clarity, and completeness of the content. Where content is missing, they send content producers back into the field to gather missing footage. A minimum amount of titling and metadata, such as tags for language and thematic category, is added for indexing into a database.

The videos are digitized on a PC and edited, using simple non-linear editing software. The videos are then either mailed as DVDs or directly uploaded, if adequate bandwidth is available, on to a searchable Internet database that makes the content available for public use under a Creative Commons license (Figure 2).

C. Mediated Instruction for Dissemination and Training

Although the videos are available on the DG Web site (http://www.digitalgreen.org), the principal means of distributing videos from the DG database to farming communities is by physically mailing or couriering DVDs. Villages are provided a minimum

Figure 2. A snapshot from the Digital Green video repository.

Figure 3. A typical night screening with farmers gathered in front of a temple in Yellachavadi, Karnataka.

of one TV and one DVD player each and battery backup equipment if necessary.

In each farming community, local mediators are hired on a part-time basis (in our study, by GREEN Foundation). These mediators are residents of the same communities in which they share DG content; this reduces the logistical challenges of regular visits to a village and provides local access to agricultural knowledge from a familiar source. In each village, the mediators conduct a minimum of three screenings per week during suitable evening hours. They transport DG equipment to different segments of their communities, maintain attendance records, and track the interest and adoption of the promoted techniques. These mediators are additionally supported by a full-time extension system (in our study, NGO) that provides mechanisms for feedback and audit for a cluster of villages. The mediators are given a performance-based honorarium of up to Rs. 1,500 (US$30) per month, which is calculated from a mutually agreed set of target metrics that take into account the local population of farmers and the agro-ecological conditions of the season.

Villages usually do not have a public forum at which farmers regularly gather, so location and timing of the screenings is a major concern. Farmers are often only willing to take a short diversion of between one to two hours from their daily routine in the evening. In addition, political and socioeconomic differences within village communities rarely permit all the farmers to gather in one place at one time. As illustrated by Figure 3, the night showings typically involve small groups of 20 to 30 farmers who are willing to come to gather at a common site within a short distance from their homes. Several small groups are formed within a single village to screen content on a regular basis, based on the availability and interests of group members. Since the screening locations preferred by each small group may differ, multiple screenings are scheduled each week on a rotational basis. Actual locations are selected by local extension agents and mediators, who typically choose accessible sites—bus stands, temples, schoolhouses, *panchayat* (administrative) offices, storefronts, individual homes, and on the streets.

Extension agents use the DG system as a tool to support their regular duties and require some training in its optimal use. Since extension agents often come from various backgrounds, videos are used to train and standardize their own interactions with farmers as well. In addition, the extension staff is shown how to integrate the DG system into its existing operations. Training introduces staff to the system, available content, and facilitation techniques. Mediation itself and training in mediation are critical elements; both roughly follow guidelines of established pedagogy for mediated instruction [15].

D. Regimented Sequencing for Initiation

Farmers' acceptance of new agricultural practices does not occur over a single video screening. So, communities are approached in a particular manner and order: First, a village gathering is organized in a central location to showcase highlights of the ser-

vices that will be provided; interested farmers are identified; new content is recorded, with extension staff introducing a particular practice to the identified farmers in the field; informal screenings of content of peer farmers are held; small groups of interested farmers are then formed with a regular schedule of content screenings (as described in the previous subsection); finally, community participation is encouraged through peer pressure to learn, adopt, and innovate better agricultural processes.

Small groups that will regularly participate in the recording and screening of DG content are also founded within existing formal structures, such as local farmer cooperatives and self-help groups (SHGs), or are initiated by the DG system itself.

While the DG Web site provides functionality to search and browse the video database, the DVDs used by the village facilitators only provide a basic navigational menu that lists the titles of the 10 to 15 videos on a single disc. Still, the order in which the content is presented is important, so mediators are trained to begin by showcasing practices that are known to provide immediate results for farmers. Local extension agents also assist in determining the sequence of the content to be shown. We try to present material that was recently recorded, as featured farmers are especially interested to see themselves "on TV." Because such recordings happen in season, the timeliness of the promoted practices also align with the issues that farmers face in the field.

V. Results

A. Methodology

A controlled study was conducted between April 2007 and April 2008 in 16 villages to evaluate the impact of the DG system.

For the study, three village clusters were selected within GREEN Foundation's operational area. The clusters were, on average, 30 kilometers apart and were similar in terms of climatic, agro-ecological, political, and cultural conditions, thus minimizing disparities in the results due to these factors. In each cluster of villages, the NGO's extension agents followed the classic T&V approach as a baseline. Extension agents visited each village in their cluster about one day per week to meet individual farmers and to perform field demonstrations.

The communities were primarily comprised of dry land, subsistence farmers; finger millet, banana, mulberry, and coconut were the major crops of the region. Farmers faced issues ranging from water and fodder scarcity to elephants trampling on fields at night.

Villages were split into two groups: (1) eight control villages where the NGO's extension agents conducted periodic training visits (T&V extension); and (2) eight DG villages where the NGO's periodic staff visits were undertaken in combination with regular DG content screenings mediated by locally hired village persons (DG system). To minimize the effects of confounding factors, an attempt was made to balance the groups in terms of population sizes, irrigation availability, and years of previous GREEN Foundation interventions.

The villages ranged in size from 50 to 80 households of which 10 to 20 had access to an irrigation facility, such as a bore well. Most families were officially designated as below the poverty line, based on the Government of India's definition of an average earning of less than 12 rupees (US$0.25) per day [16]. Still, nearly one-third of the households owned a television and one-fifth had subscriptions to local cable networks. The GREEN Foundation had worked in the communities from between two and four years prior to the introduction of the DG system; however, fewer than 10% of the households had participated in any of the NGO's previous interventions.

In the eight villages selected for the DG interventions, the videos were screened by mediators from these same communities. The eight mediators were hired on a part-time, temporary basis and represented balanced age groups and genders. They were selected on the precondition of local language literacy (for record-keeping purposes) and were issued a performance-based honorarium of up to Rs. 1,500 (US$30) per month. In each village, the mediator conducted meetings three nights per week and collected records, including farmers' attendance, feedback, and adoptions of promoted practices. These records were randomly verified on a weekly basis by GREEN Foundation's extension agents. Qualitative in-depth interviews with study participants, including the NGO's extension agents and farmers, were sampled before the study commenced. Convenience sampling was used to collect survey data.

Each of the eight DG villages incurred a fixed cost of about Rs. 9,500 (US$190) for the TV and DVD player equipment and the recurring costs of the monthly performance-based honoraria of the

mediators. Moreover, the NGO's extension agents (present in both control and DG cases) received a salary, on average, of Rs. 6,000 (US$120) per month. Since the mediators received a maximum honorarium of Rs. 1,500 (US$30) per month, the incremental cost of labor was 25%.

NGO extension agents worked with farmers to produce more than 300 videos in the local language (Kannada) of the region. The DG video repository included field demonstrations led by agri-scientists, testimonials of progressive farmers, interactions among farmers, and market-based opportunities. The videos averaged 10 minutes in length and comprised over 50 hours of content. The DG repository included the contributions of more than 50 farmers and 30 experts. The content belonged to the broad categories of crop management, animal husbandry, indigenous technologies, value-addition activities, bio-fertilizers, pest management, composting, water management, and entertainment.

Prior to the study, an initial baseline survey was performed during the first meeting in each village to ascertain the attendees' sources of information, as well as their prior knowledge of the agricultural practices that would be propagated during the study period. A sample of 236 farmers was selected for this. Then, the DG system, as described in Section IV, was implemented for a period of 13 months in the eight test villages, while the other eight control villages received the NGO's regular extension services. Seven categories of agricultural practices were sequentially promoted in both the control and DG villages, including seed treatment, kitchen gardening, *azolla* cultivation, silage, organic fertilizers, mulching, and vermicomposting. More than 1,500 screenings took place over 13 months (an average of over three per village per week), reaching more than 2,000 farmers.

During each screening, attendance records were kept, and a simple survey was undertaken, consisting of one question about whether any attendees had an interest in taking up a practice. Throughout the study period, mediators and extension staff also kept tabs on who had adopted new practices (relatively easy to do in the intimate setting of a small village).

B. Quantitative Results

Figure 4 depicts the sources of agricultural information that farmers claimed to have accessed at least once during the year preceding our study, based on our baseline survey. The main source of information for farmers in our sample was the advice of private agro-dealers. Across rural India, agro-dealers have established stalls to sell agricultural inputs, such as seeds and fertilizers, and they conduct field demonstrations to convince potential buyers of the utility of their products. Our interviews revealed that some farmers were suspicious of the agro-dealers' motives in offering information, but farmers felt that the alternatives were less accessible. A smaller percentage of farmers had been advised by a neighboring farmer, perhaps due to a similar barrier in the diffusion of fertilizer technologies that Duflo and others observed between neighboring farmers in Western Kenya [17]. Also, though some farmers had indicated they listened to media programs broadcast by the government agricultural department on TV and radio, none of the farmers had attempted any of the practices that had been featured in them.

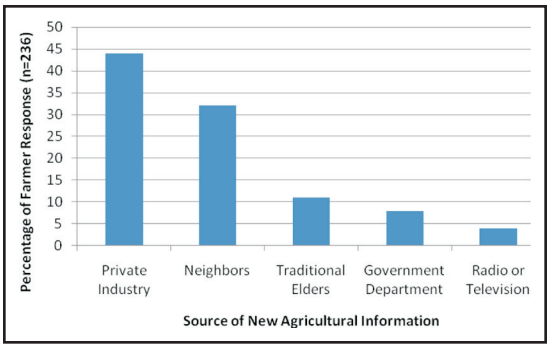

Figure 4. Sources of new agricultural information accessed by farmers at least once in the preceding year.

Regarding prior knowledge, fewer than 5% of the farmers correctly answered questions on the specific techniques that were to be promoted during the study, even though nearly 40% could describe the overall concepts. So, overall, farmers began with very little knowledge of the sustainable agriculture practices that GREEN Foundation hoped to spread.

As described in Section III, GREEN Foundation reduced the complexities of the sustainable agricultural practices being promoted by developing modules that were captured as short video clips. Depending on the nature of a practice, farmers sometimes needed to integrate the lessons from several modules to fully adopt the technique. For example, the process of setting up a vermicompost produc-

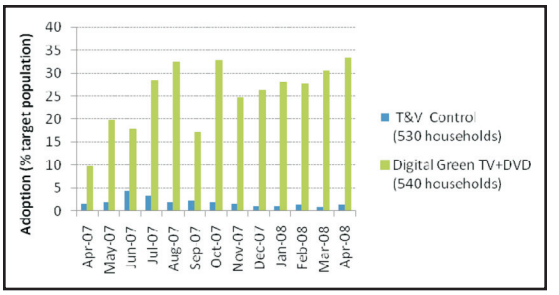

Figure 5. Percentage of farmers in the target populations that adopted at least one new practice in a calendar month from April 2007 to April 2008.

tion unit was contained in a single module that captured a demonstration of the technique. On the other hand, the adoption of the system of rice intensification (SRI) method required farmers to follow a series a multiple modules (e.g., seed treatment, planting method, water management, weeding, etc.) across the span of a farming season. Though the promoted practices varied in required investments and expected returns, GREEN Foundation's agri-scientists estimated that the adoption of any one of the promoted modules of practices would raise the income of a farmer between US$20 to US$100 each season, based on participatory research trials the NGO had separately performed.

In our controlled evaluation, we found that the set of practices adopted by farmers were nearly equivalent in both the control and DG villages across the duration of the study. Adoption rates, however, differed significantly. Figure 5 compares the rate of adoption of agricultural practices in the control villages to the DG villages on a monthly basis. Adoption levels are computed as a ratio of farmers that implemented at least one new practice during a particular period to the total number of farmers in the target group.

For the control areas, the results were consistent with the NGO's previous experience with extension, with rates of 1% to 4% of the farmers adopting a new technique per month. The low adoption rates highlight the difficulties of reaching a large, scattered population of farmers using the classic T&V approach.

In the DG villages, an average of 280 farmers attended at least one screening each month (with a range of 250 to 310). Each month, slightly more than one-half of these farmers (155 on average) indicated an interest in adopting a specific technique during the screenings. The proportion of farmers that actually implemented the practice in their fields varied from 10% to 33% in any given month.

We note that for each of the 13 months, adoption rates of the DG set over the control set were several times greater, with multiplicative factors ranging from four to 36. In the cumulative 13-month period, we found that 85% of farmers in the target communities adopted at least one new agricultural practice in the DG villages, while only 11% of the farmers in the control villages did so. We thus saw an over seven-fold increase in adoption levels with DG over the classic model. The individual monthly results do not add up to the cumulative results, because farmers who may have adopted multiple practices over several months are still only counted once in the cumulative score, and the data were normalized to the target population of the largest DG village (200 households).

Notably, NGO extension agents are often tasked with duties, such as internal training, that are broader in scope than those of agricultural extension. We estimated that extension agents spent 80% of their time in T&V control villages, convincing farmers to adopt new techniques, whereas they only spent 20% of their time doing so in DG villages.

These approximations were determined by considering the extra duties of an extension agent in a DG village. They include periodic training and monitoring of the local facilitator, field support for any immediate issues, and production of new video content with the local facilitator and farmers. The costs of GREEN Foundation's implementation of the T&V

Table 2. Cost-Benefit Analysis of Extension Systems.

Extension System	Cost (US$)/Village/Year	Adoption (%)/Village/Year	Cost/Adoption (US$)
T&V (Control)	$840	11%	$38.18
Digital Green	$630	85%	$3.70

Data are normalized for a village population of 200 households.

extension system was dominated by the salaries of its full-time extension agents. DG improved the efficiency of these agents by leveraging the local support of part-time mediators and video programming at the village level. As a result, DG effectively reduced the costs of the entire agricultural extension system by 25% on a per-village basis.

Table 2 summarizes a cost-benefit comparison of the T&V control and DG extension systems. On a cost-per-adoption basis, Digital Green was at least 10 times more effective per dollar spent than the classic extension system alone—this is extremely encouraging, and GREEN Foundation was absolutely delighted with these results.

C. Qualitative Results

Throughout the study, we also made a number of qualitative observations worth recording. These observations were not systematically tabulated, but they occurred with enough intensity that they could be the basis for further modifications to the DG system.

Self-reporting for non-adoption: In all cases, both for control and DG villages, where farmers did not adopt a practice, farmers' self-reporting cited lack of time, labor, or material resources as the reason.

Reinforcing diffusion: In a textbook example of Rogers' theory of diffusion [18], farmers appeared most swayed by videos of other farmers in the same socio-economic strata as themselves. Some videos showcased wealthier farmers in the community to inspire others to participate, but, while audiences appreciated their success, they did not appear as moved to adopt.

When those farmers featured in videos attended content screenings, mediators encouraged them to share their experiences to motivate their peers. Some were hesitant to become the center of attention, but when they came out of their shells, they were often the most effective at convincing their peers (Figure 6).

Farmers seemed to perceive relevance in a particular technique presented on video, based on audio and visual cues, such as the use of the local accent. This sensitivity extended even to inanimate property: for instance, a plastic drum used in a demonstration turned away some farmers because they possessed only earthen urns.

Figure 6. A farmer becomes an early adopter for cultivating azolla *in her community. A facilitator provides a plastic sheet to accelerate her adoption, during a DG screening.*

Value of video: The videos bootstrapped on the ability of the mediators who, we should recall, are members of the village community and generally not formally trained in agriculture. Nevertheless, they became local resource persons for their communities, if only because they were the most exposed to the training videos. In many cases, the mediators themselves were the first adopters of practices. Such mediators actually enhance added value, because they could discuss their own experiences with the new technique.

Value of mediation: In outdoor screening environments, villagers expressed boredom by leaving. The presence of mediators, however, frequently forestalled a mass departure (and, hopefully, boredom). Because mediators make the content active—they reiterate concepts between clips, ask questions to gauge comprehension, and announce follow-up visits and subsequent screenings—more members of an audience seemed to stay throughout the sessions when a mediator was present. In fact, in heavily mediated sessions, the majority of an audience would stay to the end, whereas in sessions with a passive mediator, farmers walked out quickly.

Farmer insight: During the period of the study, a few farmers experimented with some practices and discovered further improvements that better suited their local conditions. These innovations were captured on video and distributed for wider adoption.

Verifiability: Local content production allowed farmers to verify the subject matter of a video by authenticating a known source or physically visiting the recorded field. During DG screenings, viewers frequently asked for the names and villages of recorded farmers. In addition, farmers on the verge of expressing interest in a particular technique typically asked for the names of farmers in their village who had already adopted it.

Being "on TV" as an incentive: Some farmers competed to be included in the content, so that they could be seen by their peers on TV. In other cases, farmers who refused to even participate in screenings would later become die-hard DG farmers when they themselves were featured in a video. Peer content often initiated curiosity and established itself as a medium for transference through community participation.

Repetition and novelty: There was a delicate balance between achieving the right degree of repetition and novelty, and DG needed be tweaked to find the optimal point. While farmers needed to repeatedly view a video for some techniques before feeling confident enough to try it, they, nevertheless, demanded to see new farmers featured in new videos. We found that recording the same techniques being adopted by different farmers resulted in a suite of videos that were very effective at simultaneously maintaining attention and inculcating the subtleties of a practice. This fit well with the fact that appearing on video is a non-monetary incentive that encouraged farmers to adopt new practices.

Social side effects: DG does not explicitly seek to do anything but propagate good farming practices. However, because of its participatory content production and emphasis on bringing small groups together, there were instances where DG reunited estranged family members, whether they were feuding brothers or neglected widows—this effect was most frequent when the person alienated was featured in a DG video.

Overall, these findings suggest quite a few refinements of the existing DG system, as well as further studies to better understand farmer and village interaction.

VI. Related Work

A. IT for Indian Agricultural Development

Several groups have sought to provide information to Indian farmers using technology. ITC's widely acclaimed *e-Choupal* initiative and Hindustan Lever's *iShakti* program were designed as kiosk-based Web portals that would provide real-time weather forecasts and customized information to help farmers better manage their crops. While *e-Choupal* [19] has demonstrated success in streamlining the supply-chain for grain production, both programs have faced difficulties in enabling farmers to recognize value from information that cannot directly be incorporated into their existing operations [20]. IIT Bombay's *aAQUA* [21] is one service that has been deployed in kiosks to allow farmers to ask questions of agri-professionals over the Internet. Farmers typically receive answers within 24 to 48 hours, and there are indications that farmers trust the information they receive. IIIT Hyderabad's *e-Sagu* system was established on the alternative assumption that farmers have difficulty formulating the right questions to ask. In the *e-Sagu* system, local coordinators obtain the weekly crop status of a farmer's field by taking digital photographs that are compiled on a CD and mailed to agricultural scientists at the university who then prepare personalized advice for each farmer. The system has shown that farmers can realize significant economic benefits with targeted expert support [22].

Whereas the *e-Sagu* system follows a push-based model that details how individual farmers should proceed on a weekly basis, *aAQUA* captures farmer requests for information on a needs basis. Both systems have shown success in field trials, and both also require available experts to provide advice on an individual basis. In addition, *aAQUA* depends on a farmer's ability to compose an appropriate query that can be sent via SMS on a mobile phone or via a PC kiosk with Internet access. *E-Sagu* assumes these incapacities of farmers, but does not attempt to improve farmers' decision-making abilities in its push-based model.

B. Videos in Agricultural Extension

Many organizations involved in agricultural development use a variety of media to communicate with the masses. The Developing Countries Farm Radio Network (DCFRM), for example, has built reposito-

ries of scripts that organizations use for community radio programs [23]. The Government of Karnataka sponsors daily agricultural programs on public television broadcasters, like *Doordarshan,* and on *Krishi* (farm) radio; it also coordinates supplements in newspapers, like *Prajavani.* Some farmers may have access to these media sources, but the programs are often produced by experts of a different socioeconomic status in simulated conditions. Consequently, only the most progressive farmers tend to connect these programs with improving their personal farming operations. Broadcast television programs and mobile cinemas have been used in agricultural extension systems throughout the world, including the United States, Kenya, Nigeria, Uganda, and Fiji [24]. The videos sometimes complement T&V-based approaches to generate mass awareness. In the late 1970s, the World Bank supported the deployment of the PRODERITH system [25], which incorporated aspects of participatory video production and distribution in Mexico's tropical wetlands. More than 700 videos were produced, and PRODERITH successfully increased the incomes of 3,500 farmers by 50% between 1977 and 1984. The Food and Agriculture Organization (FAO) of the United Nations also supported a farmer-training project in Peru between 1975 and 1986 that recorded 1,000 videos (each about 20 minutes in duration) that reached more than 150,000 small farmers [26]. These projects and others, such as that of the Deccan Development Society in Hyderabad, India, successfully demonstrated the potential of using participatory video. Earlier, however, audio-visual technologies were cost prohibitive. These costs, however, have fallen dramatically in the last decade, and a 1996 FAO study suggested that audio-visual training activities would cost one-third to one-fifth of classical extension training [27]. On the other hand, kiosk-based interventions to connect farmers with expert information using PCs continue to be impractical for the rural conditions of the developing world due to illiteracy and undeveloped infrastructure [28]. Furthermore, farmers prefer interpersonal methods of receiving information on new or innovative farming practices over mass media methods [29].

C. Tutored Video Instruction

In the 1970s, Jim Gibbons pioneered the use of *Tutored Video Instruction* (TVI) at Stanford University [30]. Under the TVI approach, minimally edited videos of unrehearsed lectures are viewed by groups of students assisted by a "para-professional" mediator. The mediator engages students by interrupting the video lecture and asking questions and replaying segments as necessary. Gibbons showed that students in TVI sections of an engineering course not only performed better than those who watched videotapes alone, they even outperformed students who attended live lectures. The University of Washington's Department of Computer Science and Engineering attempted to use TVI in a similar manner to offer courses to local community colleges [31]. The experiment showed that the integration of video production and distribution into existing social and organizational structures is crucial for acceptance and relevance. The *Digital StudyHall* (DSH) project has extended the TVI paradigm to the context of the developing world by digitally recording the lessons of good teachers in urban centers, collecting the videos in a database, and distributing them on DVDs via the postal network to poor rural schools. DSH resolves the "impedance mismatches" [32] that exist due to the socioeconomic differences of an urban school and a rural school by localizing content in slum schools.

VII. Conclusions and Future Work

We have presented the Digital Green (DG) system, which uses participatory local video content as a basis for mediated instruction to amplify the effectiveness of agriculture extension agents. In a 13-month, balanced control study involving 16 villages, we found that the DG system is able to multiply the value of a NGO's extension agents by a factor of 10 times per dollar spent. Locally hired mediators ensure that farmers are engaged within a framework that progressively enables them to achieve sustainability in their operations.

These results, however, are not conclusive due to the small size and geographic focus of the experiment, as well as our coarse evaluation of the whole DG system, which depends on a number of factors to succeed. To investigate further, we are currently studying a variant of the DG model in which village-level mediators conduct regular meetings, using static posters as training aids instead of audio-visual technologies. This should allow us to evaluate the value of video as a medium in the current DG system.

We are also in the process of extending the Digital Green system with grassroots-level partners in South Asia and Africa. We plan to continue studying farmer participation in both the recording and screening of videos to understand the learning, adoption, and innovation of better agricultural practices in different contexts. Our preliminary assessment was restricted to capturing the awareness, knowledge, and adoption of new practices. We would ultimately like to assess the end-to-end benefits provided to farming communities in terms of agronomic productivity, as well as the adoption of practices over successive agricultural seasons to measure both their continued acceptance and quality. ■

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