Digital Green: Participatory Video for Agricultural Extension

Rikin Gandhi, Rajesh Veeraraghavan, Kentaro Toyama, Vanaja Ramprasad

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) human-mediated instruction for dissemination and training, and (4) regimented sequencing to initiate a new community.**

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 four-month trial involving 16 villages (1070 households), Digital Green was seen to increase adoption of certain agriculture practices by a factor of six to seven times over classical person-only agriculture extension. The hardware investment was a TV and a DVD-player per village, and one digital camera and PC shared among all 16 villages. These results are very preliminary, but promising.

Index Terms — **agriculture, developing nations, mediated instruction, rural areas, video-based instruction**

I. Introduction

INDIA, like most other developing nations, is still primarily an agricultural country. Over 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 (NSSO) 2005 Situation Assessment Survey of Indian Farmers studied the sources of new technologies and farming practices that farmers accessed in the preceding year [2]. Increasing debt and declining returns have led some to make desperate choices, which 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 sometimes results 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 remain common in agriculture-intensive areas, but these can be too general for practical use. The other alternative is agriculture extension, in which trained extension officers attempt to inculcate farming practices and techniques to farmers through individual interaction.

Robert Evenson describes agricultural extension efforts as following an awareness-knowledge-adoption-productivity (AKAP) sequence [4]. Guiding a farmer through this progression with respect to a particular technique is the aim of extension services. Agricultural extension in developing countries has seen a history spanning 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 & 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 in the world at over 100,000.

The scale of actual impact, however, is confounded by logistical and resource challenges that include the sheer number of households that are assigned to a single extension officer, as well as the difficulty of individual officers to establish rapport with their potential clients [6] [7]. Extension officers tend to restrict their work to richer farmers who work at larger scale in each village, as they are initially the most willing to take in input. 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 in extension is the acclaimed Farmer Field Schools (FFS) model [8]. The FFS model enables farmers to improve their decision-making capacities through weekly "informal schools" in which a small group of farmers observe and evaluate possible agricultural interventions on one individual's farm. The FFS model is claimed to have spread the adoption of Integrated Pest Management (IPM) practices in Asia by graduating more than

Manuscript received August 24, 2007.

R. Gandhi is with Microsoft Research India, Bangalore, India (phone: +91-80-6658-6000; e-mail: rikin@alum.mit.edu).

R. Veeraraghavan was with Microsoft Research India, Bangalore, India, now with the School of Information, University of California, Berkeley, CA 94720 USA (e-mail: rajesh@berkeley.edu).

K. Toyama is with Microsoft Research India, Bangalore, India (e-mail: kentoy@microsoft.com).

V. Ramprasad is with GREEN Foundation, Bangalore, India (e-mail: earthbuddy@gmail.com).

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 the fiscal viability of this model [10].

It is in this context that we present Digital Green, a technology-supported means of agriculture extension. Initially inspired by a project called *Digital StudyHall* for rural education [11], we use video as a basis for disseminating agriculture practices. The components of Digital Green are (1) a participatory process for content production, (2) a locally generated digital video database, (3) human-mediated instruction for dissemination and training, and (4) regimented sequencing to initiate a new community. Each of these components will be discussed in greater detail in Section IV.

Although video itself has been tried many times in agriculture extension before (related work will be discussed in a later section), Digital Green brings together what we believe is a novel combination of components and techniques in which the use of video is only one aspect. The more critical aspects 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.

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

II. METHODOLOGY

The work presented in this paper occurred in two stages.

In the first stage, an iterative approach 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 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 itself as well as the challenges of using video as a medium in rural areas.

Our work was done entirely in collaboration with the GREEN Foundation, a non-governmental organization (NGO) headquartered in Bangalore, India, that focuses on sustainable agriculture practices in rural Karnataka state. GREEN encourages non-chemical-intensive agriculture practices and the establishment of seed banks, which preserve the natural genetic diversity in crop species. It has a presence in 20 villages, with plans to expand to 100 in the medium term. For the purposes of the work presented in this paper, it is important to note that GREEN's methods are based in classical agriculture extension, with NGO staff members traveling to villages, going door to door to disseminate their knowledge.

Together with GREEN, the first author spent over 200 days in the field within a span of a year, during which time, extension officers were observed performing their regular extension duties and interactions with farmers were recorded. In addition, we experimented with producing various types of video content and tested alternative approaches to screening and mediation, based on initial guesses, trial-and-error, and the feedback of extension staff and farmers. A very brief summary of the experiments is listed in Table 1.

In the second stage, we fixed a particular Digital Green extension model (as described in Section IV), and conducted a four-month controlled study in 16 villages to compare farmers' field adoptions of new practices between two forms of agricultural extension: (1) the classical extension methodology, based on periodic training and field-based staff visits, and (2) Digital Green content screenings mediated by locally-hired village staff. The methodology and results of the second-stage experiment are described in Section V.

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 extension. The experiments were conducted in two villages comprising 375 households. The discussion in this section reviews some of the initial findings which 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, which featured experts, NGO staff, and farmers where 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 insert additional commentary, invite questions, or engage in discussion with the viewers. The range of mediation included straight playback with no mediation, to heavy mediation.
- Background of the mediator: *E.g.*, other farmers, extension officers, PhD experts.
- Background of people featured in video: regular farmers, low-skill extension officers, agriculture university graduates.
- Type of content: as shown in Table 1, under "Video Themes".
- Location of screening and method of dissemination: A sample is shown in Table 1, under "Screening location".
- Other factors: the presence of extra incentives such as handouts 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, consonant with previous observations [12]. For example, a progressive farmer might be considered low-skill, an extension officer with some bachelors-level education might be considered medium-skill, and a director-level extension officer with a masters or doctoral degree in agriculture could be considered high-skill. As Table I suggests, low- and medium-skilled people were generally more trusted. Interviews with farmers brought out that they had encountered many experts in the past, but that expert advice was confounding. Farmers thus expressed apathy towards expert lectures, preferring the persuasion of familiar neighbors.

Not surprisingly, the farmers' interest in video depended strongly on the 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 video with new farmers, possibly to see proof of a broader base of support for the practices.

Farmers were always sensitive to the appropriateness of the content to the current season and the tangible benefits that its application could provide. The most significant complaints about content that we heard 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 the GREEN Foundation promoted would take farmers several months to realize any improvements, but videos containing this content would not be well-received until farmers had a chance to try a technique with a shorter reward cycle.

The effect 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 over. 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. Personal DVD exchanges and cable networks enabled the videos to be seen by farmers who may have been unaware or incapable of attending public screenings. These methods tend to connect with only the most progressive farmers without the presence of a mediator, though. 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 for technique adoption were provided during the screenings. Even if this equipment was provided on a cost basis, farmers preferred to buy at the screening than to journey to a larger village or town to purchase the tools 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 provided 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.

Finally, farmers required more than a single session of video to absorb the material. Frequently, they requested the same content to be shown multiple times during a screening to build sufficient confidence to embark on attempting a procedure. In other cases, extension support was required for adoption. In the case above, of the twelve interested farmers, only three farmers successfully completed the process without any field support, three farmers began the process on their own but requested follow-up support to validate their work, and six

TABLE I
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	−

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

farmers required the full-time supervision of extension staff.

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

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) human-mediated instruction for dissemination and training, and (4) regimented sequencing to initiate a new community.

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 officer is teaching a farmer a new technique. As seen in Fig. 1, most video recordings involve three people: a teacher, a farmer, and a content producer who doubles as the cameraperson.

The content producer tries to enforce the following format in an instructional video: (a) a brief verbal overview of the process, (b) an itemization of the required resources and associated costs, (c) step-by-step instructions in the field, usually with the farmer and some times 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 officers 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 extension officers. Extension officers perform their regular extension duties, which mostly take the form of field assessments or demonstrations, and capture their interactions with farmers on a camcorder. In this way, an extension officer produces one or two clippings per field visit.

One of the critical factors in DG is the inclusion of local farmers in the instructional videos. This is a critical, but subtle feature. The placement of the farmer in a video is based on our learning that other farmers in the area are more likely to adopt a practice that is already being implemented by their neighbors. As an added benefit, the potential to appear in a video is an incentive in and of itself for the farmer to adopt a practice. And, on occasion, farmers themselves contribute insight or techniques during recordings. It is important that this possibility is not over-romanticized – in the vast majority of cases, the expertise does lie, in fact, with the extension officer, and the primary value of the farmer's participation is to demonstrate willingness to learn.

Fig. 1. An extension officer prepares to produce a low-cost, vermicompost video demonstration featuring local farmers in Bhanavasi, Karnataka.

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

The videos are captured using inexpensive, MiniDV camcorders, and tripods and external microphones are used to improve video quality.

B. Locally Generated Video Database

Content recorded in the field, like all raw footage, is usually unusable as is. DG requires at least one video editor who has basic computer literacy, some bare understanding of the nature of the content, and who can be trained in the basics of video post-production. In our case, we found this is best done by someone with at least a bachelors degree, for the discipline they can bring to bear as well as experience with formal training and critical thinking.

Video editors are the second and final point where the aforementioned 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 is added for indexing in a database, including tags for language and thematic category.

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

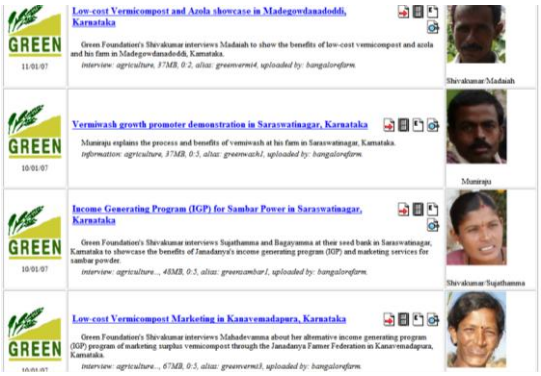

Fig. 2. A snapshot from the Digital Green video repository.

C. *Mediated Instruction for Dissemination and Training*

The principal means of distributing videos from the DG database to a village is by physically mailing or couriering DVDs. Villages are provided a minimum of one TV and one DVD player each.

In each farming community, local mediators are hired on a part-time basis (in our case, by the GREEN Foundation). These mediators are members and residents of the same communities with which they share DG content, to reduce the logistical challenges of regularly visiting a village and to provide local access to agricultural knowledge from a familiar source. Each week, 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 promoted techniques. These mediators are additionally supported by a full-time extension staff (in our case, either government or NGO), which 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$ 38) per month, which is calculated from a mutually agreed set of metrics that take into account the local population of farmers and the agro-ecological conditions of the current season.

Villages usually do not have a public forum in which farmers regularly gather, so location and timing of the screenings is a major concern. Because of the extensive time demands of farming, farmers can take only a short diversion of between 1 to 2 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 Fig. 3, the night showings typically involve small groups of 20 to 30 farmers that are willing to come together at a common place within short distance of their homes. Several small groups are formed within a single village to show content on a regular basis, based on the availability and interests of the group. Since the screening locations preferred by each small group may differ, multiple screenings are scheduled each week on a rotational basis. Actual locations are left to the extension staff and the mediator, who typically chooses from among bus stands, temples, schoolhouses, panchayat (administrative) offices, storefronts, individual homes, and streets.

Extension workers use the DG system as a tool to support their regular duties, and require some training in its optimal use. Since extension workers often come from various backgrounds, videos are used to train and standardize their interactions with farmers. In addition, the staff is shown how to integrate the DG system into its extension activities during weekly “teacher training” sessions run by a senior extension officer or the NGO. Training introduces staff to the system, available content, and proper screenings techniques. Mediation itself and training in mediation is a critical element, and both roughly follow guidelines of established pedagogy for mediated instruction [13].

D. *Regimented Sequencing for Initiation*

Introducing a village to new agricultural practices cannot occur with a single 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 services 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; then, small groups of interested farmers are 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 may be founded within formal structures of local farmer cooperatives and self-help groups (SHGs) or can be initiated by the DG system itself.

The ordering of content itself is important, and we begin with presenting practices which are known to have immediate results for the farmer. Local extension staff can 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”.


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

As such recordings happen in season, they are also aligned with what other farmers are interested in seeing.

V. RESULTS

A. Methodology

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

For the study, three village clusters were selected from GREEN Foundation's operations that were at least 30 kilometers apart. All clusters were similar in terms of language, cultural, and agronomic conditions. The extension activities of each of the three clusters were supervised by one NGO extension officer. In each cluster, the NGO extension officer followed the classical T&V approach, as a baseline. Extension officers visited each village in their cluster about one day per week to meet individual farmers and to perform field demonstrations.

The communities are primarily comprised of dry-land, subsistence farmers. Ragi, banana, mulberry, and coconut are the major crops of the region. Farmers face issues ranging from water and fodder scarcity to elephants trampling on fields at night.

Villages were split into (1) eight control villages in which periodic training and field-based staff visits were undertaken (classical extension) and (2) eight DG villages where periodic staff visits were undertaken in combination with regular DG content screenings mediated by locally-hired village persons (the DG system). An attempt was made to match the groups in terms of population sizes, irrigation availability, and the years of previous GREEN Foundation interventions.

The villages ranged in size from between 50 to 80 households of which 10 to 20 typically had access to an irrigation facility, such as a borewell. Most families are officially designated as below the poverty line, based on the Government of India's definition of earning less than 10 rupees (US$ 0.25) per day. Still, nearly one-third of the households owned a television and one-fifth had access to local cable networks. The GREEN Foundation has worked in the communities from between 2 to 4 years; however, less than 10% of the households had participated in any of the NGO's previous interventions.

In the eight villages selected for the DG interventions, content was distributed by mediators from these communities that were hired on a part-time, temporary basis. The eight mediators balance age groups and genders. They were hired on the precondition of local-language literacy, and were issued a performance-based honorarium of up to Rs. 1,500 (US$ 38) per month. In each village, the mediator conducted meetings three nights per week and collected data, including farmers' attendance, feedback, and adoptions of promoted practices. These records were randomly verified on a weekly basis by NGO extension officers. Qualitative in-depth interviews with study participants, including extension officers and farmers, were sampled before the study commenced. Convenience sampling was used to collect survey data.

Each of the eight DG villages incurs a fixed cost of about Rs. 9,500 (US$ 225) for the TV and DVD player equipment and the recurring costs of the monthly, performance-based honorariums of the mediators. Moreover, the extension officers (present in both control and DG cases) receive a salary on average of Rs. 6,000 (US$ 148) per month, whereas the mediators receive a maximum honorarium of R. 1,500 (US$ 38) per month, so the incremental cost of labor is only 25%.

NGO extension officers worked with farmers to produce over 150 local videos in the Kannada language. The DG video repository included field demonstrations led by agri-scientists, testimonials of progressive farmers, interactions amongst farmers, and market-based opportunities. The videos averaged 10 minutes in duration and comprise over 25 hours of content. The DG repository included the contributions of over 50 farmers and 30 experts throughout the DG villages (as well as earlier content generated in the first stage). The content belongs to the broad categories of crop management, animal husbandry, indigenous technologies, income generating 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 prior knowledge of the agricultural practices that would be propagated during the study period by DG. A sample of 236 farmers was selected for this, and farmers were asked pinpoint questions about some of the techniques that were to be taught over the study period. Then, the DG system, as described in Section IV, was implemented for a period of four months in the eight test villages, while the other eight received their 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 vermi-composting. Over 500 screenings took place over four months (an average of over three per village per week), reaching more than 1,000 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 (this is relatively easy to do in the intimate setting of a small village).

B. Quantitative Results

Fig. 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. In close similarity to the results of the 2005 NSSO survey, the farmers in our sample primarily relied on the advice of private agri-businesses that sell seeds and fertilizers. Surprisingly, fewer farmers had been advised by a neighboring farmer and fewer still had consulted an extension officer. These results may be

biased by the sample of farmers that attended the first community meetings; however, Duflo *et al.* found a similarly unexpected barrier in the diffusion of fertilizer technologies between neighboring farmers in Western Kenya [14]. Also, though some farmers had indicated that they listened to the media programs that are 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.

As for their knowledge of the practices that were to be taught during the study, less than 5% of the farmers correctly answered questions on specific techniques, 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 for adoption of practices, the types of practices that were adopted by farmers were nearly equivalent in both the control and DG villages. Adoption rates, however, differed significantly. Fig. 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 communities.

For the control areas, the results were consistent with the NGO's previous experience with extension, with rates of 2% 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, a little more than one-half of these farmers, 155 on average, indicated an interest in adopting a specific technique during the screenings. And, between 9% and 26% of the farmers actually implemented the practice in their fields.

We note that for each of the four months, adoption rates of the DG set over the control set were several times greater, with multiplicative factors ranging from four to seven. The cumulative results show that after four months, 55% of farmers in the target communities adopted at least one new agricultural practice in the DG villages whereas only 8% of the farmers in the control villages were adopters of a new practice (the individual monthly results do not add up to the cumulative results, as farmers who may have adopted multiple practices over several months are still only counted once in the cumulative score). We thus saw a nearly seven-fold increase in adoption levels of DG over the classical model – this is extremely encouraging, and GREEN Foundation was absolutely delighted with these results.

Despite the striking results, however, we caution that we cannot draw conclusions about what the gains can be attributed to. In particular, the relative value of video as a medium, versus the systematic approach of the mediated instruction remains unclear.

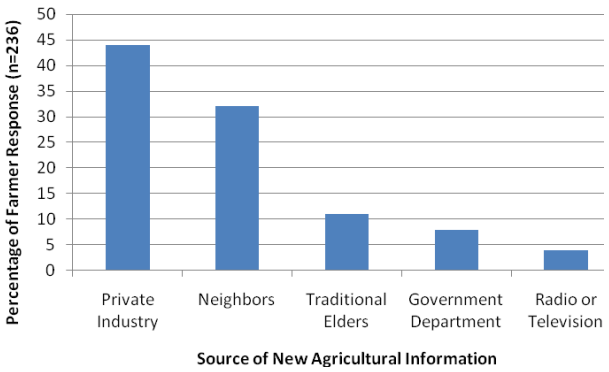

Fig. 4. Sources of new agricultural information accessed by farmers at least on one occasion in the preceding year

C. *Qualitative Results*

Throughout the study, we also made a number of qualitative observations that are 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 where farmers did not adopt a practice (both for control and DG villages), farmers' self-reporting cited lack of time, labor, or material resources as the reason.

Reinforcing diffusion: In a textbook example of Rogers's theory of diffusion [15], farmers appeared most swayed by videos of farmers who were in the same socio-economic strata as themselves. In some of the videos, wealthier farmers in the community were showcased to inspire others to participate, but, while audiences appreciated their success, they did not appear as moved to adopt.

The quality of content recorded as members of a community attempt a particular practice sometimes diminished as experts become unavailable in the field; however, expert content juxtaposed with farmer content provided both training and motivation for others to try the same.

When recorded farmers attended content screenings, mediators encouraged these farmers to share their experiences to motivate their peers. Some farmers expressed hesitation to

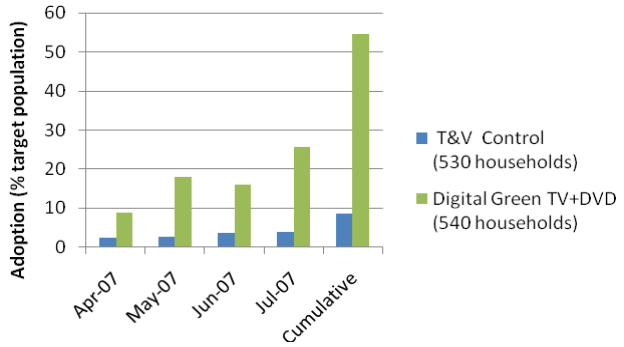

Fig. 5. Percentage of farmers in the target populations that adopted at least one new practice in a calendar month and cumulatively from January to June 2007.

become the center of attention, but when they came out of their shells, they were often the most effective at convincing their peers (Fig. 6).

The notion of homophily extended even to correspondences in inanimate property. A plastic drum, for instance, used in a demonstration turned away some farmers because they possessed only earthen urns.

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

Value of mediation: In outdoors 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, through reiteration of concepts between clips, questions to gauge interest, and announcements of follow-up visits and subsequent screenings, more of an audience seemed to stay throughout when they were present. In fact, in heavily mediated sessions, the majority of a group 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.

Verifiability: The local generation of the content allowed farmers to verify actual instances appearing in 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 other farmers in their village who have already tried the same.

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 refusing even to 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 see video of a specific technique multiple times before feeling confident enough to try it, they nevertheless demanded new farmers in new videos. We found that recording the same content with different farmers resulted in a suite of videos that were very effective at simultaneously maintaining attention and also 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.

Fig. 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.

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 brought estranged family members back together, 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

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 agriculture, video in agriculture extension, and mediated instruction for effective training with video. Ultimately, the hope is that DG is able to weave together the best of these three strands of work into a single system that maximizes the impact of agriculture extension workers.

A. IT in 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. *e-Choupal* [16] has demonstrated success in streamlining the supply-chain for grain production, however, both *e-Choupal* and *iShakti* have faced difficulties in enabling farmers to recognize value from information that cannot directly be incorporated into their existing operations [17]. IIT Bombay's *aAqua* [18] is one service that has been deployed in kiosks to allow farmers to

ask questions to agri-professionals over the Internet. Farmers typically receive answers after 24 to 48 hours, and there are indications that farmers trust the information that they receive. The *e-Sagu* system was established on the alternative assumption that farmers are unable to ask the right questions. In the *e-Sagu* system, local coordinators obtain the weekly crop status of a farmer's field by taking digital photographs. These photographs are compiled on a CD that is mailed to agricultural scientists at the university, who prepare personalized advice for each farmer. The system has shown that farmer can realize significant economic benefits with targeted expert support [19].

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 a SMS-enabled phone or 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 tend to use a variety of media to reach the masses. For example, the Developing Countries Farm Radio Network (DCFRM) has built repositories of scripts that organizations can use for community radio programs [20]. Others, such as the Government of Karnataka, sponsor daily agricultural programs on public television broadcasters, like *Doordarshan*; on *Krishi* (farm) radio; and supplements in newspapers, like *Prajavani*. Some farmers may have access to these media sources, but the programs are typically produced by experts of a different socioeconomic status in model conditions. Consequently, only the most progressive farmers tend to connect the programs with improving their personal farming operations. Broadcast television programs and mobile cinemas have been used in agricultural extension system throughout the world, including the United States, Kenya, Nigeria, Uganda, and Fiji [21]. 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 [22], which incorporated aspects of participatory video production and distribution, in Mexico's tropical wetlands. Over 700 videos were produced, and *PRODERITH* successfully increased the incomes of 3,500 by 50-percent 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 of about 20 minutes in duration that reached more than 150,000 small farmers [23]. 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 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 [24]. 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, which include illiteracy and undeveloped infrastructure [25]. Furthermore, farmers prefer interpersonal methods of receiving information on new or innovative farming practices over mass media methods [26].

C. Tutored Video Instruction

In the 1970s, Jim Gibbons pioneered the use of *Tutored Video Instruction* (TVI) at Stanford University [27]. 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 performed better than those that watched the videotapes alone, even out-performing the students who attended live lectures. The University of Washington's Department of Computer Science and Engineering similarly attempted to use TVI as a method to offer courses to local community colleges [28]. The experiment showed that integration of video production and distribution into existing social and organizational structures is critical to their acceptance and relevance. The *Digital StudyHall* (DSH) project has extended the TVI paradigm 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" [29] that exist due to the socioeconomic differences of an urban school and a rural school by localizing content in slum schools.

The DG system differs from previous work by using cost-realistic technologies, like TVs and DVD players, to build the capacities of farmers to 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 localized to a region and feature the participation of familiar farmers, as opposed to experts in idealized conditions. In addition, village-level mediators facilitate the showing of these videos to ensure that farmers personally connect with the content on a regular, accessible basis.

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 impact of agriculture extension officers. In a four-month control study involving 16 villages, we found that the DG system, at a cost of approximately $300

per village + 25% increment beyond extension-officer salaries, is able to multiply the value of extension officers by seven or eight times that of classical extension. Locally-hired mediators ensure that farmers are engaged within a framework that progressively enables farmers to achieve sustainability in their operations.

These results, however, are far from conclusive due to the small size 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 recently began a study to understand a variant of the DG model in which village-level mediators conduct regular meetings without the use of audio-visual technologies and use static posters instead. This should allow us to study the value of video as a medium in the current DG system.

We also plan to study farmer participation in both recordings and screenings to understand the learning, adoption, and innovation of better agricultural practices. The 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.

ACKNOWLEDGMENT

The authors specially thank the GREEN Foundation team for inviting us to work so closely with them in the field and the many farmers that welcomed us into their homes.

REFERENCES

[1] G. D. Stone, "The Birth and Death of Traditional Knowledge: Paradoxical Effects of Biotechnology in India," In C. McManis (ed.), *Biodiversity and the Law: Intellectual Property, Biotechnology and Traditional Knowledge*: 207-238, Earthscan, 2007.

[2] National Sample Survey Organization (NSSO), "Access to Modern Technology for Farming, Situation Assessment Survey of Farmers," 59th Round, Report No. 499, Government of India, Ministry of Statistics and Programme Implementation, New Delhi, 2005.

[3] G. D. Stone, "Agricultural Deskilling and the Spread of Genetically Modified Cotton in Warangal," *Current Anthropology*, 48:67-103, 2007.

[4] B. E. Swanson, R. P. Bentz and A. J. Sofranko, *Improving agricultural extension: reference manual*, Food and Agriculture Organization of the United Nations, Rome, 1998.

[5] J. Anderson, G. Feder, S. Ganguly, "The rise and fall of training and visit extension: an Asian mini-drama with an African epilogue," *Policy Research Working Paper Series, No. 3928,* The World Bank, May 2006.

[6] C. H. Antholt, "Agricultural Extension in the Twenty-first Century," In C. K. Eicher and J. M. Staatz (eds.), *International Agricultural Development*, Third edition, Baltimore, MD., The John Hopkins University Press: 354-369, 1998.

[7] G. Feder, A. Willett, and W. Zijp. "Agricultural Extension: Generic Challenges and the Ingredients for Solutions," In S. Wolf and D. Zilberman (eds.), *Knowledge Generation and Technical Change: Institutional Innovation in Agriculture*. Boston, Mass, Kluwer, 2001.

[8] R. Tripp, M. Wijeratne and V. H. Piyadasa, "What should we expect from farmer field schools? A Sri Lanka case study," *World Development*, 33(10): 1705-1720, 2005.

[9] H. Van den Berg and J. Jiggins, "Investing in Farmers – The Impacts of Farmers Field Schools in Relation to Integrated Pest Management," *World Development*, 35(4): 663-686, 2007.

[10] A. C. Rola, J.B. Quizon and S.B. Jamias, "Do Farmer Field School Graduates Retain and Share What They Learn?: An Investigation in Iloilo, Philippines," *Journal of International Agricultural and Extension Education*, 5(1): 65-75, 2002.

[11] R. Wang, U. Sahni, S. Sobti, N. Garg, J. P. Singh, M. Kam, A. Krishnamurthy, and T. Anderson, "The Digital StudyHall," Technical Report TR-723-05, Computer Science Department, Princeton University, March 2005.

[12] R. Gandhi, "Digital Green Experiments," Working Draft, Microsoft Research India, Bangalore, February 2007.

[13] R. J. Anderson, M. Dickey, H. Perkins, "Experiences with tutored video instruction for introductory programming courses," *SIGCSE*: 347-351, 2001.

[14] E. Duflo, M. Kremer, and J. Robinson, "Understanding Technology Adoption: Fertilizer in Western Kenya: Evidence from Field Experiments," Mimeo, MIT, April 2006.

[15] E. M. Rogers, *Diffusion of Innovations*, Free Press, New York, 2003.

[16] A. Karnani, "Fortune at the Bottom of the Pyramid: A Mirage," November 2006, *Ross School of Business - Working Papers Series*, February 2007. Available: http://ssrn.com/abstract=914518

[17] R. Kumar, "eChoupals: A Study on the Financial Sustainability of Village Internet Centers in Rural Madhya Pradesh", *Information Technologies and International Development*, 2(1):45-74, September 2004.

[18] K. Ramamritham, A. Bahuman and S. Duttagupta, "aAQUA: A Database-backended Multilingual, Multimedia Community Forum (A Demonstration)," *SIGMOD*, Chicago, June 2006.

[19] B. V. Ratnam, P. K. Reddy and G. S. Reddy, "eSagu: An IT based personalized agricultural extension system prototype--analysis of 51 Farmers' case studies," *International Journal of Education and Development using ICT (IJEDICT)*, 2(1), 2006.

[20] W. Amt, "DCFRN: a radio network for farmers," *Development Communications Report*, 52: 11-10, 1986.

[21] R. Engelhard, "ICTs - transforming agricultural extension?" *Proceedings of CTA's Observatory on ICTs*, Leiden, 2003.

[22] C. Fraser and Restrepo-Estrada, "Communication for Rural Development in Mexico," The Food and Agriculture Organization of the United Nations, Rome, 1997.

[23] C. Fraser, "Pioneering a New Approach to Communication in Rural Areas: The Peruvian Experience with Video for Training at Grassroots Level," The Food and Agriculture Organization of the United Nations, Rome, 1987.

[24] G. Coldevin, *Participatory communication: a key to rural learning systems*, The Food and Agriculture Organization of the United Nations, Rome, 2003.

[25] R. Kuriyan and K. Toyama (eds.), "Review of Research on Rural PC Kiosks," 2007.

[26] L. E. Riesenberg and C. O. Gor, "Farmers' Preferences for Methods of Receiving Information on New or Innovative Farming Practices," *Journal of Agricultural Education*, 1989.

[27] J. F. Gibbons, W. R. Kincheloe, and K. S. Down, "Tutored videotape instruction: A new use of electronics media in education," *Science*, 195(3):1139-1146, 1977.

[28] R. Wang, U. Sahni, N. Garg, N. Dasgupta, S. Sobti, T. Setia, and T. Anderson, "Digital Networking Going Postal and Tale of Three Schools," *Small Change Magazine*, India, January 2005.