The *Journal of International Agricultural and Extension Education (JIAEE)* is the official refereed publication of the Association for International Agricultural and Extension Education (AIAEE). The purpose of the *JIAEE* is to enhance the research and knowledge base of agricultural and extension education from an international perspective. Acceptance rates for the past three volumes are: Volume 19 = 20%, Volume 20 = 21%. Volume 21 = 13%. Volume 22 = 18%. Volume 23 = 12%.

Articles intended for publication should focus on international agricultural education and/or international extension education. Articles should relate to current or emerging issues, cite appropriate literature, and develop implications for international agricultural and extension education. **Manuscripts, or portions of manuscripts, must not have been published or be under consideration for publication by another journal.** Three types of articles are solicited for the *JIAEE*: Feature Articles, Tools of the Profession Articles, and Book Reviews.

**Feature Articles**
Feature articles focus on philosophy, current or emerging issues, and the methodology and practical application of specific research and appropriate technologies, which have implications for developed and developing countries. For publication in the *JIAEE*, feature articles must pass the *JIAEE’s double blind, referee process*, where peer reviewers evaluate manuscript content and ensure readability. Reviewers are selected from the AIAEE membership. In the double blind, referee process, all references to authors are removed before the manuscript is sent to reviewers. Feature articles may be submitted for peer review a total of three times before they are no longer acceptable for publication in the *JIAEE*. Failure to meet the submission formatting guidelines will result in an automatic first rejection.

**Other Article Types**
Commentary articles state an opinion, offer a challenge, or present a thought-provoking idea on an issue of concern to international agricultural and extension education, including a published article in the *JIAEE*. These articles are invited by the editors. Tools of the Profession articles report specific techniques, materials, books and technologies that can be useful for agricultural and extension educators in a global context and/or in a country/region. Book Reviews provide insight on current books related to international agricultural education.

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From the Executive Editor

Wow! What an issue. This is the largest group of articles I have had the pleasure of working to get the first issue of volume 24 in print. I hope you enjoy reading the diversity and thought provoking questions produced by these authors. Do not forget to submit your scholarship for review. Submission guidelines are located at: https://aiaee.org/index.php/submission-guidelines. Please remember that we accept submissions for tools for the profession, book reviews, commentaries, and feature articles. The editorial team enjoys the diverse amount of scholarship that is submitted on a regular basis.

In this issue, there is a book review that outlines the historical context of communicating for development and social change. A tools for the trade submission offers readers an appraisal of elements that influence farmer’s adoption of agricultural innovations in South Africa. This issue includes a commentary that discusses current political outcomes that will impact funding levels for food security and international agricultural and extension education projects and a method for Malawian practitioners to be prepared.

Seven feature articles are included in the first issue of Volume 24. The first feature article focuses on motivations of women to pursue agricultural careers. Next, you learn the results of a SWOT analysis from Cambodia concentrated on the capacity development of agricultural education and training. Implications for extension educators are presented from data associated with risks to children in cocoa households in Ghana. The influence of gender, awareness, and social status on attitudes and adoption of rainwater harvesting in Kenya are in this issue. Data regarding Ugandan and Kenyan farmer’s adoption of conservation agriculture and use of agricultural information networks are presented here. Additionally, the adoption and diffusion tendencies of Kenyan farmers in Uasin Gishu County are given for our understanding. The seventh feature includes attributes and barriers of innovations predicting U.S. nursery and greenhouse growers’ use of water conservation technologies. I hope you find articles in this issue informative, challenging, and authored by individuals with similar inquiries as yours. Do not forget to submit your work to the JIAEE for review. The profession wants to learn about your findings and how you are working to advance our profession.

I look forward to interacting with those of you attending our annual conference!

Sincerely,

Robert Strong Jr.
Executive Editor, JIAEE
Book Review

 Saving the World: A Brief History of Communication for Development and Social Change  
 By: Emilie McAnany (2012)  
 Urbana, IL: University of Illinois Press  
 181 pages, including index and reference lists  
 $27.00 paperback

Drew F. Slattery  
 Oklahoma State University

Overview

Emile McAnany published his text Saving the World: A Brief History of Communication for Development and Social Change as part of a University of Illinois commissioned multi-volume series on the history of communication and communication studies in 2012. McAnany uses his more than 50 years of scholarly communication research and international development practice to trace the history of Communication for Development (C4D) from its inception post World War II (WWII) with the Marshall plan to the current time, through four major paradigms. Put simply, this book illustrates the use of communication by development practitioners as it has evolved over time, culminating in a series of recommendations by the author based on the lessons learned associated with this history.

The text begins with an introductory framing in which the author discusses his stance on and role in the subject as well as his assumptions, biases, and professional experience. McAnany (2012) operationalizes the term C4D as the use and role of communication in international development and social change (pp. 3-6). Development and social change are further defined by the author as the improvement of a person’s standard of living as a result of either institutional or societal/individual level changes, respectively. The development field, in the context of McAnany’s thesis, includes U.S. government departments, such as USAID, inter-governmental bodies, e.g., the United Nations (UN), and private or faith-based Non-Governmental Organizations (NGOs) which implement development programs. Early in the text, McAnany mentions the disagreements over terminology and other issues amongst practitioners of international development, but states firmly that his intent is not to be distracted by differing semantics and political orientations, but rather focus on the subject at hand.

According to McAnany, the four historical C4D paradigms were born from and influenced by three theoretical frameworks as espoused by Daniel Lerner, Everett Rogers, and Wilbur Schramm, respectively. These theoretical foundations and their importance to each paradigm are described in detail as the text moves through the history of C4D. The first paradigm discussed is the modernization-diffusion paradigm, which began in the years following WWII. During this epoch of C4D, McAnany describes the power of mass media infrastructure, of its expansion, and of subsequent media campaigns it emanated to catalyze national development efforts. Next is the dependency, or critical paradigm emerging in the 1960s and early 1970s. This
period was characterized by top-down programming through a political economy framework which benefitted the program implementers but included little to no local input or buy-in, hence its name.

According to McAnany, ascension of the participatory paradigm began in the 1980s and remains prominent today. The participatory paradigm is one in which C4D activities are built around a two-way relationship, with an active and engaged audience cooperating with program implementers to bring about development as a team. Finally, McAnany discusses the emerging paradigm of social entrepreneurship. This paradigm, although not yet dominant, is quickly expanding to become an important force in development. In this approach, C4D activities emerge from within the specific social systems and locales which face development challenges; they are not brought in from outside agencies or external sources. Such communication activities are built around a business model intended to be self-sustaining with no need for reliance on outside funding or inputs for survival.

The various paradigms along with their successes and failures are presented in chronological order by corresponding decades, and woven together with the author’s conclusions as to why each paradigm succeeded or failed to the extent it has, as well as how their performances are and should be measured. The text culminates in a series of recommendations for future C4D activities based on the author’s interpretation of lessons learned over time.

**Evaluation**

The aims of this text are to provide a history of C4D activities during the last five decades; offer insight into the practical, theoretical, and historical contexts of various C4D successes and failures; discuss how the impacts of C4D are determined and what that means for the field; and put forth an academically rigorous set of recommendations for future C4D programs. McAnany firmly accomplishes these goals across his eight chapters.

The major historical paradigms presented in the text are richly detailed and thoroughly developed. A commendable job is done by the author of diving deeply into each paradigm; presenting the historical context of the paradigm’s creation and birth; how it grew to be widely accepted and utilized as the prevailing methodology; the impact of the paradigm over time and what it achieved; as well as the failures and limitations of the paradigm and how that led to the reinvention and overall evolution of the C4D field. This approach enabled McAnany to make several sound and thoroughly referenced claims as to both how and why the field of C4D evolved over time. By providing an exhaustive context of the situation, the reader gains a robust understanding of the nuanced theories, applications, and history of C4D.

The strengths of this work lie in its judicious use of reference material, ranging from real-world practical examples and project reports to theoretical suppositions and peer-reviewed publications. Including such extensive referential material creates a history lesson which does much more than simply recount what transpired over the decades. McAnany presents the evolution of C4D as embedded within a broad but rigorous academic context while exhaustively linking said evolution to the events, publications, and milestones that shaped it.

A notable weakness of the text worth mentioning is that McAnany assumes readers are familiar with some of the concepts and phenomena about which he writes. The concepts, however, may not be readily accessible to someone new to the
fields of communication or international
development, versus readers already well-
versed in their respective jargon, study, and
practice. At times, McAnany’s writing can
be rather dense and academic, which may
create a barrier for readers less acclimated to
this style of writing.

**Recommendation**

Although this text is not centered
around agricultural education and extension
specifically, it does hold great relevance and
value to both theory and practice within the
field and is highly recommended to anyone
working, studying, or researching at the
intersection of communication and
international development. First, the text is
exhaustively referenced using a diverse
body of peer-reviewed, governmental, and
well-known theoretical sources. As such, it
serves as an extensively detailed *literature
review* for both the field of communication
and its practice in international development
and related change efforts during the past
60-odd years. This creates an ideal research
node for scholarly inquiry into the subject
matter by connecting readers to an array of
relevant works in communication and
international development. The text includes
an extensive index section, making the quick
reference of specific phenomena and follow
up with related resources easily accessible.
In addition to its value as a reference, the
text is recommended to planners designing
international development programs with a
C4D framework or component. The scope of
historical and evolutionary causation
described in the text, could serve as a
valuable foundation for any C4D-related
program design going forward. The
recommendations and lessons which
McAnany presents carry with them immense
insight for the practice and use of
communication in development.

**Reference**

McAnany, E. (2012). *Saving the world: A
brief history of communication for
development and social change.*
Urbana, IL: University of Illinois
Press.
Introduction

Research has revealed that different factors influence adoption of agricultural innovations by farmers. These factors include characteristics of innovations comprising relative advantage, complexity, compatibility, trialability and observability as discovered by Rogers (1983), and technology characteristics, information sources, knowledge, awareness, attitude, and group influence (Odale, 2005, p. 250). The diffusion model was considered the main theoretical model for agricultural extension and the development of agricultural advisory services (Padel, 2001, p. 40). The diffusion process influences the success or failure of agricultural development programmes. Factors influencing adoption of agricultural innovations were appraised by reviewing selected empirical studies. This could influence agricultural communication agents to consider the interaction of factors in the diffusion and adoption process in designing their communication strategies in the light of improving adoption.

The conventional wisdom is that constraints to the rapid adoption of innovations involve factors such as, limited access to information, lack of credit, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to curb labour shortages preventing timeliness of operations, chaotic supply of complementary inputs and inappropriate transportation infrastructure (Feder, Just & Zilberman, 1985, p. 255). Although factors influencing adoption have been widely researched, it is the consideration of these factors that has remained largely unexplored in developing countries due to several challenges (Servaes, 2002). An appraisal of how the factors influencing adoption of agricultural innovations interact could promote adoption. The study reviewed empirical studies of diffusion of agricultural innovations in five selected developing countries: Uganda, Thailand, Indonesia, Zimbabwe and India.

Interaction of factors in the diffusion and adoption of agricultural innovations

A study conducted by Howley, O’Donoghue and Heanue, (2012) in relation to advanced breeding technologies such as AI by Ugandan dairy farmers revealed that the age of the farmer, and years of awareness of the AI technology (compatibility), total farm milk production and sales (observability), extension visits per year, and quality of AI services provided to the farmers (communication strategies) were associated with adoption and use of AI technology. Therefore, it was concluded that experience with AI is positively associated with the likelihood of its use. Age was negatively associated with AI use in that relatively older farmers were found to be much less likely to use AI than younger age cohorts. In that study, compatibility in the form of awareness, observability of the benefits of the new innovation and communication in the form of extension visits influenced farmers to adopt the innovation. However, the older the farmers, the less likely they use advanced reproductive technologies.

In a study on adoption of sweet pepper cultivation in Thailand by Schipman and Quain (2010) between 1999 and 2007, adopters were more often female and were younger and better educated than non-adopters. Age negatively influenced adoption behaviour, whereas education had a positive impact. Given the complexity of sweet pepper cultivation (that is, greenhouses with hydroponics systems), it was understandable that younger and better-educated farmers were more likely to adopt the innovation (Schipman & Quaim,
Market and information accessibility (communication channels) had a positive influence on adoption, which was as expected and was shown in other studies as well (Schipmann & Quaim). Notably, age negatively influences the adoption of more complex technologies and younger farmers adopt more advanced technologies than older ones. Education has a positive influence on adoption of complex technologies. Communication also, was a positive influential factor in adoption.

The FAO conducted a study among rice farmers in Indonesia, during the wet season of 1992-1993 (Feder, Murgai, & Quizon, 2004). The study compared costs of rice farming inputs and outputs among ten farmers who had participated in Integrated Pest Management Farmer Field Schools (IPM-FFS) during the previous wet season with practices and outputs of ten farmers who had never participated in farmer field schools. Overall, the IPM farmers achieved 21 percent more rice harvest yield on a per hectare basis (6.9 tons versus 5.7 tons), for 97 percent of production costs, when compared to their non-IPM farmer counterparts. The significantly lower input costs for IPM farmers were largely attributed to minimal usage of commercial pesticides. The study findings suggested that FFS have a positive effect in influencing adoption. It discernible that if this innovation was to spread to more farmers, it could have been adopted for its relative advantage of cheap input costs, low labour costs and high yields.

A study by Maumbe and Swinton (2000) in Sanyati in the Midlands Province of Zimbabwe examined the adoption of different cotton pest management practices by smallholders in transition from conventional calendar-based chemical pest control to Farmer Field School-Integrated Pest and Production Management (FFS-IPPM) strategy. The study revealed that an extension approach, FFS influenced adoption of IPPM. Therefore, investment in IPPM farmer education and literacy programmes targeted to non-adopters was anticipated to have long-term beneficial impact on IPM use. Success of IPM adoption depends on farmer’s knowledge and awareness of the technology (compatibility). The findings indicated that extension delivery is an important driver in the adoption process.

The study conducted by Rao (2008) in India indicates that use of information and communication technologies such as the e-Choupal, enhances better decisions on various agricultural practices among users as compared to non-user farmers. Users of e-Choupals were more educated, belonged to higher social category with higher income and had larger landholdings.

**Implications**

Overall, communication of agricultural innovations has emerged as the major desirable prerequisite in adoption of innovations as revealed by the findings of the studies reviewed in all the five countries and should therefore be as effective as possible. Considering the dynamic state of media technologies, extension workers’ ICT skills need to be improved in developing countries so that they could transfer these to farmers since ICTs have proved effective in delivering a variety of information which enhances better decision-making. Age and education have also emerged as major influential factors in adoption.

All the studies indicated that while age is negatively associated with adoption, education and social class is positively associated with adoption. Therefore, effective strategies are such as diligent stakeholder analysis are required to motivate all farmers to adopt modern and high yielding technologies considering the dynamic state of knowledge. Communication of agricultural innovations should be contextualised as much as possible in order to tailor it to suit the needs and situations of the particular farmers. Agricultural institutions should spearhead the upgrading of their communication agents’ knowledge and skills so that they communicate effectively to improve adoption of innovations that are high yielding. Most importantly, a diligent stakeholder analysis, multimedia and multi-strategy approaches to agricultural communication should be considered in order to increase adoption and consequently productivity since agriculture is the main source of livelihood in developing countries.

**References**


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Commentary

Forecasting Future Funds for Food Security Projects: A Reflection on Trainings for Frontline Extension Staff on Improved Agricultural Practices in Malawi

Hector M. Malaidza
Malawian Ministry of Agriculture

Robert Strong Jr.
Texas A&M University

Abstract
Eighty percent of the Malawian population depends on agriculture for employment. This commentary is a reflection of a number of training workshops conducted to orient frontline extension staff on improved agricultural technologies. These trainings were conducted by the Technology Transfer Unit (TTU) is under the Department of Agricultural Research Services (DARS) of the Ministry of Agriculture, Malawi. The manuscript contains an analysis across various activities were done before, during, and after a number of technical training sessions. The manuscript presents a detailed picture of processes associated with implementation of the trainings where technical information was shared. The results conceptualize insights of things what was effective, and suggests ways of improving trainings in the future. Therefore, this commentary stresses on the importance of conducting training needs assessments for specific technical groups. The lessons drawn from the analysis are sketched in a general schematic model that can be used for designing, implementing and evaluating future agricultural extension staff trainings to improve food security of Malawians.

Keywords: training, agricultural extension, agricultural technologies, technology transfer
Introduction

Due to recent national elections and referendums in the United States and the United Kingdom, the future of funds allocated to develop nations is in question. Historically, developed nations in the Western world have delineated funds to help less fortunate nations build their capacity to be able to trade and strengthen alliances with the respective developed nations (Huish, 2006). A change in political winds has offered new evaluations and questions about where developed nations spend funds, for what, and to whom. The potential impact of assisting less developed nations expand their capacity offers new markets, political associations, military infrastructures, and educational opportunities to developed countries (Paris, 2006). The effect of funding projects to enhance human capital is difficult to quantify but imperative to support given the need to improve individual’s living conditions and decrease opportunities for conflict to arise (Minniti & Naudé, 2010). With the uncertainty of future support provided by the West, developing nations may have to rely more on themselves, Chinese, or Russian aid to combat food insecurity.

Development funds have been designated to supporting extension organizations address food insecurity. Acquiring funds or seeking funding sources for extension programming is not new. Davis (2016) suggested extension systems crusade for increased funding regardless of budgetary environments. Moore and Harder (2015) cited deficient funding as a barrier for extension in Liberia. With decreased budgets for food security projects, there will be reduced funds available to support agricultural extension.

Malawi is a sub-Saharan African nation that attributes over 35% of the GDP to agriculture (United Nations, 2016). The Food and Agriculture Organization (FAO) of the United Nations (2015) reported that 80% of Malawians depend on agriculture for employment. More than a decade ago, the Department of Agricultural Research Services (DARS) in Malawi conducted trainings to orient frontline extension staff on newly released technologies. A close link exists between DARS and other Departments under the Ministry of Agriculture (MoA) in Malawi. The units include Animal Health and Livestock, (Crop Development, Department of Agricultural Extension Services (DAES), Fisheries, Irrigation and the Land Resource and Conservation.

The major linkage of all the sister Departments of the Malawian MoA is the DAES. From 2000-2010, the level of interaction among the departments was very high. These interactions were channelled through a Technology Transfer Unit (TTU) of DARS. They delivered trainings and developed extension materials in unison. These trainings kept most frontline extension staff up-to-date on recent technologies developed by the National Agriculture Research System. This approach strengthened the flow of up-to-date and quality information among key players in the agricultural innovation system (Meena, 2014).

Over the years, that culture of collaborative efforts has been lost. The trainings are not available, and extension materials are not being developed collectively. This change has resulted in information gaps creating emergencies among senior extension staff, frontline extension personnel, farmers and other stakeholders. This shows that the main pathway (trainings) of communicating agricultural information and improved technologies to extension staff is under-utilized. Owing to the importance of training of agricultural extension staff, this paper analyzes a number of trainings to develop a
The importance of capacity building through trainings has been stressed by the Agricultural Sector Wide approach (ASWAp) implementation plan which guides implementation of various promotion activities in the MOA of Malawi. The ASWAp strategy explains that the higher level of agricultural production and productivity can be achieved by improving knowledge and skills of existing technical staff, including frontline extension staff. It further expresses that trainings can either be long-term or short-term programs. This strategy also indicates that trainings should be conducted in response to results from Core Function Analyses (CFAs). These CFAs have been conducted across various departments under the MoA. It further extend discussions to details should be observed before-during-and-after (BDAT) when conducting training workshops. This commentary analyzed a number of trainings implemented by the TTU of DARS. It makes an in-depth assessment of the sessions, as individual sessions or as a set of several sessions.

**Purpose and Objectives**

The primary objective of the training was to promote drought tolerant maize varieties and associated practices through workshops and associated print media in Lilongwe Rural, Dedza, Ntcheu, Balaka, Mangochi and Machinga Districts. Four objectives guided the trainings:

1. Orient frontline extension on current technological developments on drought tolerant maize production;
2. Share field experiences on performance of drought tolerant varieties promoted by frontline extension staff;
3. Collectively develop protocols for mounting demonstrations for disseminating drought tolerant varieties and associated practices; and
4. Evaluate training content for further improvement.

The trainings were attended by frontline extension staff from Lilongwe, Dedza, Ntcheu, Balaka, Machinga, Mangochi, Mangochi, Zomba and Chiradzulu districts (see Figure 1). These extension workers were selected based on their capacity to train others. Simply, this was a platform for the training of trainers. A total of three hundred seventy-eight frontline extension staff from nine districts were trained in seven different training sessions. A majority (70%) of the trainees were male; 30% were female.
The facilitators were encouraged to adhere to the content that will help in achieving the goal of the training workshop. If circumstances arose where a facilitator was deviating from the main content, a co-facilitator intervened by raising a hand, making a brief summary, and provided a strategy to progress. This was a technique discussed and agreed during the planning meeting for delivery of the trainings. It was advised that facilitators were not to argue during the sessions but to purposely construct and deliver the learning content.

Program administrators recorded and documented comments, remarks, suggestions, questions and participants’ answers. Note takers were advised to not concentrate on recording the presentations because PowerPoint files contained the
content from the presenters and were to be shared.

Audio recordings and printed paper cards were used to capture discussions to complement the rapporteurs’ notes. Program administrators used their smartphones or uni/multi-directional audio recorders to capture video clips. The printed paper card (see Figure 2) was issued to the participants for their name and comments or questions.

| Name………………………………….. | Date: ………….
| Title of Presentation: …………………………………… |
| Comment/Remark/Suggestion/Questions:……………… |
| ……………………………………………………………… |
| ……………………………………………………………… |
| ……………………………………………………………… |
| ……………………………………………………………….. |

**Figure 1.** Printed paper card for trainees’ comments

This implies multiple ways of taking notes from the training sessions should be engaged. This helps to have reliable information and feedback for developing reference materials responsive to the participants’ needs. It also provided rich information for reporting.

Issues, experiences and feedback on technology performance were captured and to which thoroughly responded. Action plans that rose from the discussions were recorded and the strategy was mapped. In addition, responsibilities for every action point was entrusted to specific individuals.

Several activities were implemented immediately after and sometime after the trainings. These activities included a training review meeting; some follow-up activities (such as mounting of demonstrations); back to office impact; and ongoing communication with the participants.

A review meeting was conducted a day after completing the training workshops. This meeting provided an opportunity to reflect on activities which were well-done and those which needed improvement in the future. It also provided an opportunity to analyze, synthesize, and draw lessons on the data collected from evaluation of the training sessions. Facilitators who attended the review meetings alluded that all dissemination activities, such as seed fairs, product fairs, field days, and village meetings, should be included for future trainings. They expressed that review meetings can help in improving many extension activities.

The training workshops were resource intensive. They consumed financial, human, and time resources to be effectively implemented. The return on investment in trainings should be evaluated. They should achieve their goals. They should enrich the extension workers’ knowledge base and also provide them a platform to express their perceptions of the performance of existing technologies. On the other hand, they help researchers and policy makers capture feedback and adoption status of available agricultural technologies.

**Conclusion and Recommendations**

Key elements were followed in conducting the training workshops that imparted technical knowledge among frontline agricultural extension staff. Those primary components are outlined in the BDAT training model (see Figure 3). In addition, authors recommend the BDAT
model be used as a checklist for organizing future technical training sessions for frontline agricultural extension staff in Malawi and in other developing nations. The authors also recommend trainers should do further analysis and refine the tool as necessary. The size and content within the boxes in the model shows that much work conducting such trainings is concentrated at the planning stage versus during or after the program.

![Figure 3. A model for conducting trainings to frontline agricultural extension staff](image)

The trainings discussed in this paper, provided an opportunity for researchers and extension staff to share knowledge and experiences on recent developments in research and performance of existing technologies. These trainings also provided a platform for capturing feedback to research on areas for further research as well as failures and gaps on dissemination of DT maize varieties. They also helped in capturing indigenous ways and means for dealing with issues in maize production as well as feedback on performance of various technologies developed by the National Agricultural Research System. Trainings of this kind should be conducted frequently to reduce the knowledge gap between agricultural research professionals and frontline extension workers. As a consequence, this will increase the reliability of extension staff and the effectiveness of their delivery of extension-services.

Agricultural extension staff trainings are vital to the agricultural development of Malawi. They equip frontline agricultural extension staff with recent developments on...
new agricultural technologies and with appropriate information on existing agricultural innovations. Equipping frontline agricultural extension staff assists the government to have a critical mass of dependable extension staff that can train farmers to work effectively and efficiently. The agricultural extension staff are key professionals in training farmers in providing technical support to NGOs and other stakeholders and in managing many public initiatives in Malawi (Meena, 2014).

The trainings enhance food security at household and at national levels meaning that farmers are able to have enough food for their homes throughout the year. In addition, these farming households have surplus food and cash crops for sale. Proceeds from the sale help them have cash to pay for education, medical bills, transport, and energy, among others. Malawi, as a country, is able to have sufficient agricultural products for export earnings to finance its development activities while reducing food imports.

Regardless of future funds developed nations allocate to food security programs, extension systems must continue to document the impact of their trainings and promote agricultural innovations that improve food security. The data will help extension personnel at all levels advocate for increased extension funding (Davis, 2016) by utilizing successful programs that improve the livelihoods of citizens (Minniti & Naudé, 2010). Political cacophony will change but the need to promote the benefits of international agricultural and extension programs to prevent food security issues will endure.

References


Increasing Female Enrollment for Agricultural Programs of Study in Sub-Saharan Africa: What Motivates Women to Pursue Careers in Agriculture?

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Abstract
Women in developing countries, especially in Sub-Saharan Africa (SSA), play a critical role in ensuring food security and sovereignty for their families and nations. Unfortunately, in spite of this, their significance in the agricultural sector is seldom fully appreciated. Further, very few women in SSA are professionally trained agriculturists (Beintema & Di Marcantonio, 2009; Kanté, Edwards, & Blackwell, 2013), which has likely contributed to their low productivity per hectare in the agricultural sector compared to their male counterparts (O'Sullivan, Rao, Banerjee, Gulati, & Vinez, 2014). This study investigated the experiences of young, aspiring female agriculturists from Uganda who were members of Young Farmers’ Clubs (YFC) at high school to understand better how their club experiences may have impacted their career choices. Findings indicate the participants’ YFC activities, especially supervised agripreneurship projects (SAPs) and field trips, had transformative impacts on their choosing to study agriculture. However, gender stereotypes associated with females pursuing agricultural careers were still prevalent and discouraged them from becoming professional agriculturists. More research should be conducted about the impact of subjective norms (Ajzen, 1991) on females preparing to pursue careers in agriculture.

Keywords: careers, female agriculturists, Sub-Saharan Africa, Young Farmers’ Clubs
Introduction and Background

Some reports indicate females in Africa constitute 60% to 80% of the agricultural labor force (Beintema & Di Marcantonio, 2009; Ben-Ari, 2014) and contribute nearly 80% of the overall food production (Ajambo & Synnevåg 2011; Ben-Ari, 2014). These estimates, however, are disputed by other sources, especially in regard to Sub-Saharan Africa (SSA) for which reports indicate females constitute approximately 45% to 50% of the agricultural labor force (Food and Agriculture Organization [FAO], 2011; Mehra & Rojas, 2008; O’Sullivan, Rao, Banerjee, Gulati, & Vinez, 2014; Palacios-Lopez, Christiaensen, & Kilic, 2015; The World Bank, 2016). This discrepancy notwithstanding, the output per hectare of females is lower compared to their male counterparts (O’Sullivan et al., 2014).

Further, researchers (Beintema, 2006; Kruijssen, 2009) have reported low enrollment of females studying agriculture at the post-secondary level. For example, Kruijssen (2009) indicated only one-fourth of the students enrolled in agriculturally related courses at the post-secondary level in SSA were female. In regard to agricultural researchers, Beintema (2006) posited only 20% of the scientists in most agricultural research organizations in developing countries were women. The low enrollment coupled with a high attrition rate (Beintema, 2006) has resulted in a shortage of female professional agriculturists in SSA (Beintema & Di Marcantonio, 2009; Kanté, Edwards, & Blackwell, 2013).

According to Kathleen Lay, “[i]nvesting in women’s economic empowerment is a high-yield investment, with multiplier effects on productivity, efficiency and inclusive growth for the [African] continent” (as cited in Ben-Ari, 2014, p. 25). Lay further contended: “The African farmer is primarily a woman farmer. And she is a good farmer who can feed her family and her continent if she is given the tools and the opportunities to do so” (as cited in Ben-Ari, 2014, p. 25). To that aim, empowering females to pursue agricultural careers in SSA could be an efficient and effective way to improve food security and family livelihoods because women are more likely to expend resources on their families than men (FAO, 2014).

Moreover, “[e]very woman in agriculture that a young girl meets in her formative years, whether she is a farm manager, extensionist, or science teacher, is a model for the future profession that she will choose [emphasis in original]” (The World Bank, 2009, p. 262). Efforts to encourage girls to enroll in science-based subjects at the elementary and high school levels, such as agriculture, may go a long way to ensuring more females pursue science-based programs of study, including courses related to food production, during their tertiary education (The World Bank, 2009). Such an approach is likely to increase the number of professional female agriculturists, which may ultimately increase food security and economic empowerment in communities leading to improved livelihoods (Ashby et al., 2009). However, if the professional women in agriculture are not visible in newspapers, on radio . . . and in research organizations and extension offices, it is doubtful that women primary and secondary school students will become inspired to prepare for careers in agriculture, let alone in agricultural research and extension. (The World Bank, 2009, p. 272)

In a study describing the intent of Young Farmers’ Club (YFC) members to pursue careers related to agriculture at the post-secondary level, Mukembo, Edwards, Ramsey, and Henneberry (2015) reported...
the female participants in their study were less likely and more undecided than their male counterparts about pursuing careers related to agriculture. Further, Mukembo (2013) recommended follow up studies be conducted with female students who were members of YFCs and pursued careers related to agriculture to understand better how club experiences may have impacted their career choices.

**Purpose of the Study**

This study’s purpose was to explore and derive meaning from the shared experiences of females who were members of YFCs at secondary schools in Uganda, and learn how they were influenced to pursue career preparation in agriculture at the post-secondary level. Two overarching questions guided this study: (a) What were the participants’ experiences as members of YFCs? (b) How did the participants’ experiences as members of YFCs influence their decisions to pursue career preparation in agriculture?

**Theoretical Lens**

This study was framed initially by two theoretical lenses: The theory of planned behavior (Ajzen, 1991) and human capital theory (Hartog & Van den Brick, 2007; Hornbeck & Salamon, 1991; McFadyen, 2006). A third theory, feminist epistemology (Anderson, 1995; Baber, 1994; Ring, 1987), emerged during the course of analyzing and interpreting the study’s data (Guba, 1981; Lester, 1999). According to Guba (1981), “[a]dherents of the naturalistic paradigm [emphasis added] prefer to have the theory emerge from the data themselves” (p. 78). Integration of the three theories provided a basis for interpreting the study’s results.

Regarding the theory of planned behavior (Ajzen, 1987, 1991), if an individual has a positive attitude about a behavior and society approves, congruence exists with perceived control over such, and, therefore, it is possible to predict with some certainty a person’s proclivity for the behavior. Further, Ajzen (1991) posited “perceived behavioral control, together with behavioral intention can be used to predict behavioral achievement” (p. 184).

Moreover, individuals and society as a whole can build their human capital by investing in education – formal and informal – which, in turn, brings about returns to individuals, communities, and nations (Hornbeck & Salamon, 1991; Mukembo, Edwards, Ramsey, & Henneberry, 2014; Nafukho, Hairston, & Brooks, 2004; Schultz, 1972, 1981).

Feminist epistemology, as posited by Anderson (1995), Baber (1994), and Ring (1987), is concerned with how gender impacts an individual’s acquisition, understanding, and utilization of knowledge in real-world settings from a feminist perspective. Feminist epistemology focuses on how “socially constructed conceptions and norms of gender and gender-specific interests and experiences [impact] the production [or acquisition] of knowledge” (Anderson, 1995, p. 54). Traditionally, women have been marginalized as the weaker sex and portrayed as less competent than males through stereotypes and the distribution of labor along gender-based lines (Anderson, 1995; Baber, 1994; Kelsey, 2006). Males dominate in “the ‘intellectual’ fields of politics, science, and religion while women have been assigned the primary responsibility for many day-to-day tasks necessary for physical survival” (Baber, 1994, p. 5).

**Methodology and Participant Recruitment**

The researchers obtained permission from Oklahoma State University’s Institutional Review Board to conduct
research with human subjects. A phenomenological approach (Creswell, 2013; Groenewald, 2004; Guba, 1981; Moustakas, 1994) was followed in this study. Phenomenology is a flexible approach to qualitative inquiry and accords investigators opportunities to probe emerging themes that may arise during the course of a research study (Holroyd, 2001). This inquiry was grounded on Tracy’s (2010) procedural guidelines for a high quality and ethical study, including “(a) worthy topic, (b) rich rigor, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethics, and (h) meaningful coherence” (p. 839). Maintaining high ethical considerations is a critical component of qualitative research to ensure participants’ privacy and protection (Creswell, 2013; Orb, Eisenhauer, & Wynaden, 2000; Yin, 2011).

The study’s participants were purposively selected using snowball sampling (Creswell, 2013; Patton, 1990) and recruited through the online social networking service, Facebook. The lead researcher knew and contacted one of the individuals who recommended other potential participants; they also referred their peers, i.e., a snowball approach. As a result, invitation messages were sent to the Facebook inboxes of 13 potential participants; all were Ugandans. Ten replied and indicated their willingness to participate in the study; they also provided their electronic mail addresses. The individuals who agreed to participate in the study were requested to provide their Skype names for the purpose of conducting online video interviews. Seven participants provided their Skype names and were interviewed. Polkinghorne (1989) and Creswell (2013) indicated that when exploring people’s lived experiences, it is ideal to interview five to 25 persons who experienced the phenomenon.

Data Collection, Analysis, and Interpretation

The participants agreed to be video recorded during the interviews. The interviews were done via Skype and recorded simultaneously using EvaerR software in March of 2014. Online video interviews have become an effective way to gather quality data in social science research, especially if face-to-face interviews are not feasible due to logistical constraints (Bertrand & Bourdeau, 2010; Deakin & Wakefield, 2014). Deakin and Wakefield (2014) stated: “Video calling provides the researcher with an opportunity to not just talk to the respondent but to see them in real time” (p. 4). Further, “the only differentiation between Skype interviewees and face-to-face interviewees [is] geographical proximity” (Deakin & Wakefield, 2014, p. 607).

We used a semi-structured interview protocol with two overarching questions (Creswell, 2013; Groenewald, 2004; Lincoln & Guba, 1985; Yin, 2011) to guide the interviews. The participants were also asked probing questions to gain clear insight and rich descriptions of their experiences (Creswell, 2013; Yin, 2011) as members of YFCs until no new information emerged, i.e., data saturation was reached (Groenewald, 2004). Each interview lasted from 45 to 60 minutes. Rich rigor was achieved by encouraging the participants to reflect on and share life changing moments about their experiences in YFCs (Ary, Jacobs, Razavieh, & Sorenson, 2006; Merriam, 2009; Tracy, 2010). In addition, the two lead researchers kept notes or memos during the interviews (Groenewald, 2008). Groenewald (2004) stated memos may include “field notes recording what the researcher hears, sees, experiences and thinks in the course of collecting and reflecting on the [research] process” (p. 13).
The data were transcribed verbatim by the researchers and member checking was done by sending each participant her transcript to verify it for accuracy and make clarifications, as needed (Richards & Schwartz, 2002; Tracy, 2010; Yin, 2011). Member checking helps to ensure the credibility and trustworthiness of the data (Groenewald, 2004; Harper & Cole, 2012; Lincoln & Guba, 1985). The participants’ identities were replaced in the transcription process with pseudonyms to protect their anonymity.

We used the qualitative data analysis software program ATLIS/ti to organize and categorize the transcriptions into codes. “A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (Saldaña, 2016, p. 4). Equal weight was given to the participants’ responses, i.e., horizontalization of data occurred (Merriam, 2009; Moustakas, 1994) and such were later reduced to significant statements. Negotiations between the lead researchers were ongoing throughout the coding process to reach an understanding and interpretation of the data, which provided multivocality (Tracy, 2010). The codes were categorized as to what participants experienced in YFCs and how they experienced it (Creswell, 2013; Moustakas, 1994; Polkinghorne, 1989) and grouped to determine themes based on the researchers’ judgments (Moustakas, 1994; Ryan & Bernard, 2003). The coding yielded eight themes from which the study’s essence was distilled, i.e., a “common or universal condition or quality without which a thing would not be what it is” (Husserl, 1989, p. 43).

Personal bias may have been a limitation of the study because one of the lead researchers was a patron (advisor) to YFCs and also a former high school agriculture teacher in Uganda. To minimize this limitation, he bracketed his personal opinions or preconceived ideas to maintain sincerity, honesty, and objectivity (Creswell, 2013; Merriam, 2009; Moustakas, 1994; Tracy, 2010). Tracy (2010) posited “sincerity as an end goal can be achieved through self-reflexivity, vulnerability, honesty, transparency, and data auditing” (p. 841). The lead investigators collaborated with other researchers who had no prior experience with the phenomenon, which helped to further minimize personal biases that could have impacted the study’s findings. Moreover, reflective journals were kept by the lead investigators throughout the research process (Guba, 1981; Tracy, 2010). Triangulation was achieved by examining secondary sources of data, such as literature and photographs about participants’ activities, which helped enhance the validity and credibility of the study’s findings (Merriam, 2009).

Phenomenology allows researchers to draw meaning and understanding of a phenomenon as experienced by the participants (Creswell, 2013; Merriam, 2009; Polkinghorne, 1989; Van Manen, 1990), and ultimately distill its unique essence (Creswell, 2013; Merriam, 2009; Moustakas, 1994). Even though caution should be taken when generalizing the study’s results beyond its participants, readers are advised to make personal judgments on how the study’s findings may be transferable to other populations who experienced a similar phenomenon (Lincoln & Guba, 1985; Tracy, 2010). Transferability “is achieved when readers feel as though the story of the research overlaps with their own situation and they intuitively transfer the research to their own action” (Tracy, 2010, p. 845). Provision of a detailed description of the study’s participants enhances a reader’s ability to understand who provided the data and how transferable the findings
may be to similar groups (De Lay & Swan, 2014).

**Description of the Study’s Participants**

The seven participants who provided data for this study were former members of YFCs during their high school education in Uganda. They had either studied or were studying agriculture at various tertiary institutions in Uganda or elsewhere in SSA. The participants’ ages ranged from 21 to 25 years. Two participants had graduated with a bachelor’s degree in an agriculturally related field and the other five were pursuing such degrees.

**Participant #1 (Laura):** Laura was a second year student (sophomore) pursuing a bachelor of science degree in environmental science. She was 22 years old and had been the project manager of her YFC while in high school. The environmental science cohort at her university had 40 males and 25 females.

**Participant #2 (Vicky):** Vicky was a first year student (freshman) pursuing a bachelor of science degree in agriculture. She was 21 years old and had been an active member of her YFC. Her agricultural cohort at the university included seven females and 33 males.

**Participant #3 (Jennie):** Jennie was second year student (sophomore) pursuing a bachelor’s degree in veterinary medicine. She was 22 years old and had been the chairperson of her YFC in high school. Her veterinary cohort included 13 females and 43 males.

**Participant #4 (Fiona):** Fiona was 25 years old and had graduated with a bachelor’s degree in food processing and technology. She was the chairperson of her YFC in high school. Fiona was working for a honey processing company. Fiona’s university graduation class included 30 females and 70 males.

**Participant #5 (Alma):** Alma was a second year (sophomore) pursuing a bachelor of science degree in agriculture at a university in Uganda. She was 23 years old and served as treasurer of her YFC during high school. Her university cohort included 15 females and 40 males.

**Participant #6 (Marie):** Marie was working as an extension agent in Uganda. She graduated with a bachelor’s degree in agricultural land use and management from a university in Uganda. During high school, Marie was a farm prefect as well as an active member of her YFC. Marie’s university cohort included 17 females and 18 males. At her workplace, only two females worked alongside 20 males.

**Participant #7 (Riana):** At 24 years of age, Riana was pursuing a bachelor’s degree in agriculture and majoring in crop science. In her university cohort, Riana was the only female who studied with three males. She was an active member of the YFC at her high school.

**Findings**

**Theme #1: Experiential learning, related career awareness, guidance, and exploration**

All participants indicated experiencing hands-on, minds-on learning activities in real-world settings through the supervised agripreneurship projects (SAPs) implemented by their YFCs. This reinforced their understanding of agricultural concepts and related careers. They were trained to operate farm machinery such as driving tractors and also had hands-on learning experiences on how to conduct routine livestock management practices at their school farms, e.g., dehorning, castration, vaccination, and drenching. Further, the participants grew maize, plantains, tomatoes, green peppers, carrots, and planted trees on the land provided by their schools. They also reared poultry and supplied eggs as well as meat to the school cafeteria. This enabled them to earn income from the projects and opened their minds to view SAPs as businesses. “We got a good yield of maize which we supplied to the school kitchen [cafeteria] which was good. I
could not imagine a class of 10 girls supplying maize to the whole school,” said Laura. Marie added: “We grew maize, carrots, tomatoes and all those were incorporated in the school feeding program. . . . If we could sell our produce to the school, it was a sign that you could grow [crops] and you have [a] market.”

A majority of the participants indicated that initially, because of parental influence, they were mostly interested in pursuing careers related to human medicine. However, participation in their clubs’ SAPs had a positive and transformative impact regarding their views on agricultural careers. The SAPs enabled them to become aware of and to explore agricultural careers in real-world environments. Moreover, some of the agriculturists with whom they interacted during their field visits to agricultural research stations and trade fairs, exchanged with as guest speakers, or were family members and role models inspired them to pursue agricultural careers. For example, Jennie explained:

The activity which had an influence on my career choice was animal husbandry and that is why I took up the career [veterinary medicine], but of course I [initially] wanted human medicine but then I saw practically how people in animal husbandry do stuff not only in class work . . . but [also] in the field.

Marie added: “When that professional from Makerere University came and talked to us . . . he is one of the persons who encouraged me to take up agriculture.” Laura indicated her grandfather was a great role model: “My grandfather was an agricultural officer and he kept telling me about the opportunities that agriculture offers.” Further, Riana stated: “When they were providing career guidance, I literally thought I was going to be a medical student so I only looked out for guidance in the medical field.” However, through field trips and interacting with other role models in agriculture, Riana changed her mind and opted to pursue an agricultural career.

**Theme #2: Tangible benefits associated with YFC activities and SAPs**

Participants indicated they received and experienced a number of tangible benefits from their club activities. These benefits included earning money from the sale of products, consuming their harvests, and being able to make proper nutritional choices. For example, Marie attested: “We sold the maize to the school which was eaten by the students, implying that there was [a] market and then money at hand.” This was also confirmed by Alma, Fiona, and Jennie. Moreover, the money earned from selling their harvests was shared with other club members. Jennie added: “We sold the harvest . . . and gave profits to every active member.”

The participants acknowledged one of the most enjoyable club activities was feasting on their harvests after a hectic planting season. Vicky said: “We used to enjoy eating maize during the harvesting period.” This experience was echoed by others. Jennie affirmed: “The positive experience was eating what we harvested.” Further, they became aware of nutritional components of the various foods they grew, which helped them make better eating choices. Vicky shared: “I learnt more about the types of foods I should be eating to keep my life and body health through our club activities.” Jennie acknowledged that through her YFC’s activities she became aware that to live a healthy and productive life, a person had to make the right food choices to grow and to eat. She said: “When you fall sick and they take you to the hospital, before they give you medicine, they first consider your diet.”
Theme #3: Acquisition of leadership, agripreneurship, and other life skills

Six of the seven participants indicated they acquired life skills such as leadership, proper planning, budgeting, agripreneurship skills, time management, networking, accountability, teamwork, patience, persistence, and perseverance by participating in their YFCs. Alma reported: “I was a treasurer [of my YFC] and it actually helped me to get good leadership skills.” And Fiona explained: “As a chairperson of YFC, I really learnt how to be a good leader . . . . It really felt nice when we would do things together and they came out good.” Jennie added: “I learned a lot of things through the club, sometimes we would plant carrots or green pepper but they [could] be affected by weather, everything ends up being a loss but despite all this, we kept on moving.”

Laura, who was a project manager in her YFC, said: “The company I had in [my YFC] kept me moving forward . . . . even in times of crisis.” She added: “I learnt to believe in myself that I can do everything but it takes time and patience.” Vicky also described her experience:

I used to have a negative attitude toward agriculture but through my participation in the Young Farmers’ Club, I learnt that I do not need to look for a job but create it myself at home . . . . Actually, when I left school, I planted millet and cassava [at home] and I gained something.

Marie attributed her good communications skills to club participation: “I campaigned and became an agriculture prefect courtesy of the [oratory] skills I acquired in [my] YFC.”

Theme #4: Inspirational and life changing moments

Participants reported a number of inspirational and life changing moments they attributed to their experiences in YFCs and related SAP activities. Some indicated fascinating discoveries about agriculture through the clubs’ activities and how these experiences contributed to their pursuing agricultural studies at university. For example, Vicky said: “When I went for the agriculture show in Jinja, I saw new varieties of crops . . . . I even saw seeds for a banana with my eyes I had never seen [before].” And Riana described her first time to see an incubator:

I had not known about artificial incubators apart from knowing there was a hen sitting on the eggs [to incubate] but when I saw it, I was impressed and I said ‘wow this is something.’ . . . it opened my eyes that there is still business in agriculture.

Jennie revealed her love for animals started during club activities and are likely the reason she was studying veterinary medicine. She said: “I remember going to the farm to dehorn, castrate, and vaccinate; this made me love animal husbandry.” Laura added: “Tree planting in my YFC taught me to love the nature and the world around me and I think that is the reason I am doing environmental science.” Further, some participants indicated the guidance and counseling from their clubs’ patrons (advisors) was a source of inspiration. In accord, Alma said:

I remember our patron telling us to be flexible in life and keep a positive attitude . . . . Though I wanted medicine, when I was given agriculture, though I did not like it much, I really adjusted because I had seen a good future in it and I remembered most of the words he used to tell us . . . . I really adjusted positively towards the [agriculture] course[s].
Theme #5: Challenges experienced in high school

Parental expectations.
Most of the participants reported experiencing pressure from parents to pursue careers in a medical field rather than agriculture. According to Fiona, “in Uganda, when you do medicine, it’s more prestigious than agriculture . . . [and] most parents would want to see their daughters [become] doctors.” Vicky added: “When you do physics, chemistry, biology, and math, people expect you to go for medicine and surgery.” Further, Alma said: “They[,] my parents[,] wanted me to go for nursing but, fortunately, when I got a government scholarship, they had no option since at least it saved them the burden of paying tuition.” And Laura stated: “My father basically wanted me to be a doctor . . . my mum encouraged me to put agriculture as my plan B.”

Negative attitudes toward agriculture.
The participants experienced a number of challenges from peers as well as from their communities while members of YFCs. According to Vicky, the comments and attitudes of her peers toward agriculture were demoralizing. Vicky also shared what she was told by one of the elders in her community: “You are wasting a lot of money and energy doing agriculture instead of coming back home . . . Are you going to school to learn how to handle a hoe or how to pull a rope?” Fiona added: “People think agriculture is about holding a hoe very early in the morning, you go dig in the field and return home in the evening.” Laura also had been discouraged from studying agriculture because of its wide scope of coverage and it would be too demanding. Further, according to Marie, some people associated agriculture with misery and human drudgery. She said: “People think that when you do agriculture, you will be [struggling] with animals.”

Theme #6: Challenges experienced at college/university and the workplace
Some participants indicated various challenges they faced at their schools and workplaces, especially from male peers. For example, they reported discrimination and isolation from their male classmates when forming discussion groups. According to Vicky,

[when forming discussion groups, it is hard for guys to put you in their discussion groups. They always say you ladies you also form your own discussion group since you are among the superior ladies who managed to come here.]

Laura added: “Basically, boys tend to think they are the smartest in class but then I believe, and I know, that a woman is smarter . . . .”

In the case of Marie, working in extension, the cultural norms associated with a woman riding a motorcycle, and wearing trousers in public, were a big challenge. She said:

. . . my parents told me not to put on trousers and to ride a motorcycle in the community. When you put on the trousers the community perceives you negatively. . . . I have failed to express myself when addressing a community [if dressed in trousers]. So I have to move with a skirt and change before I can address a crowd which I find very challenging.

Further, two participants indicated disappointment in their mentors for not walking the talk. For example, Vicky shared: “They tell us to be practical but you find an agricultural officer without a farm.” Jennie recalled one incident at the university where they were conducting some animal operations but the instructor was scared of handling the cow. She described the incident:
The guy [teacher] was telling us to sit on the head [of the cow] to keep it restrained on the ground when he was 40 meters [away] from the animal. . . . We ended up not performing the operation we were supposed to do because everybody was scared of the animal.

Theme #7: Application of knowledge and skills for self-employment and improved livelihoods

The participants indicated continuing to apply what they learned through their YFC experiences. Several explained they would use the acquired knowledge and skills to implement various agricultural projects for self-sustenance and community improvement after graduating from higher education. Vicky stated: “I plan to set up an agro-based shop to sell equipment. . . . I would also like to set up a non-profit organization to improve animal breeds in villages.” Jennie looked “forward to opening up several projects like piggery and poultry,” and Alma planned to raise goats which she described as easy to manage and highly marketable in her area. Moreover, Fiona planned to develop a large commercial farm in her village. She said: “I plan to set up a large scale agriculture operation, planting trees and [rearing] animals.” Finally, Laura planned on returning to her home village and develop her parents’ idle land.

Theme #8: Recommendations on how to increase female enrollment in agricultural programs of study and encourage their pursuit of related careers

Participants proposed three initiatives to increase the enrollment of female students in agricultural programs of study and encourage more women to pursue agriculture as a career path.

Facilitating student-owned SAPs and related recognition opportunities.

A majority of participants indicated that providing SAPs to be owned and managed by students would incentivize more females to take agriculture courses in high school which may influence them to pursue careers in agriculture. Jennie offered: “I think introducing projects [and] giving profits to every member would act as an incentive.” And Vicky added: “Set up projects whereby the girls can actively participate, for example, planting [crops] and rearing [livestock], where they can also benefit. . . .” To that aim, Alma added: “Encouraging students to get involved in agriculture projects like YFCs builds a background for them to learn more about agriculture and its benefits.” Further, according to Jennie, “giving them certificates for their participation would encourage others.” The participants’ sentiments are supported by various occupational-minded groups, such as the International Labor Organization (2014), and by other researchers. For example, Montpellier (2014), Mukembo et al. (2014, 2015), and Mukembo and Edwards (2015) urged the promotion of agripreneurship in schools through projects as a way to motivate young people to pursue careers in agriculture, including agribusiness opportunities.

Field trips.

Taking students on field trips provides opportunities for networking and exposure to various career opportunities in agriculture. According to Riana, “when we visited different places of poultry it really changed my perception about agriculture and it is something I cannot forget.” In support, Laura said: “You get to go to many places like agricultural shows and eventually you start loving agriculture.” And Fiona contended: “Taking them to research institutes . . . where they can learn more
about agriculture” is one way to expose and motivate females to pursue careers in agriculture. The participants’ perspectives are supported by Mukembo (2013) who recommended using field trips to arouse students’ interests in agriculture.

**Female role models.**
Career guidance about the opportunities in agriculture, especially from female role models, would act as an inspiration for girls. Marie explained:

> Visit mainly girl’s schools and inform them how agriculture has progressed. . . . We need women to advocate . . . that’s what I am doing now with the primary schools and high schools, we are trying to show children how agriculture can transform their lives.

Laura also suggested the need to reach out to girls and make them aware of the career opportunities available in the agriculture sector. She said: “You reach out to the young children like high school, the ones in senior one and senior two, you tell them about agriculture, the opportunities agriculture has, what agriculture is all about.” Such an approach may be helpful in creating favorable attitudes toward agriculture at an early age (Mukembo et al., 2014, 2015). The idea of having female role models to inspire young women to pursue agricultural careers was also emphasized by the World Bank’s (2009) report *Gender in Agriculture*.

**Conclusions**

_The power of real-world experiences to create agricultural career awareness among young females and foment their drive to overcome obstacles to pursue such careers formed the study’s essence._

Although agriculture was not the first career option for most of the participants, the experiences and meanings they derived from various YFC activities, especially SAPs and field trips, gave them a different outlook on agriculture as a potential career path. The participants realized agriculture was a viable venture for self-employment and livelihood improvement. They also became more aware of agricultural careers outside the farm.

Further, negative societal perceptions about agriculture as a career choice were still prevalent and remained a barrier to female enrollment in agricultural programs of study in SSA. Parental expectations and perceptions of agriculture as a low wage, low return endeavor continues to negatively affect students’ considering agricultural studies and career preparation. The participants’ parents preferred they follow career paths in human medicine because such was perceived as more prestigious and rewarding.

The subjective norms (Ajzen, 1987, 1991; Ajzen & Madden, 1986) were unfavorable toward females and hindered their ability to perform job duties involved in agricultural careers (Anderson, 1995). If individuals perceive their society, parents, mentors, and peers approve of their engagement in a behavior, they are more likely to actualize that behavior (Ajzen, 1987, 1991). Females are a minority in almost all the professions related to agriculture in SSA (Beintema & Di Marcantonio, 2009; Kanté et al., 2013), which puts them at a disadvantage. Stereotypes and prejudices remained prevalent to the extent some participants were segregated during learning experiences at school and faced gender-based barriers at their workplaces.

**Recommendations**

Though not generalizable, these recommendations may hold transferability to similar settings. Developing student-owned projects by which students apply learning from class in real-world contexts provides
hands-on, minds-on learning experiences (Dewey, 1951), which may improve personal self-efficacy and influence career choice (Bandura, 1986; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Mukembo, 2013; Tang, Pan, & Newmeyer, 2008). Dewey (1951) also posited involvement in interesting experiences increases the learner’s curiosity for further inquiry. Students developing and managing SAPs are likely to acquire increased interests in agriculture and become more curious about related careers and livelihoods.

Early career awareness about the diverse opportunities available in agriculture may go a long way in helping to increase female participation (Mukembo et al., 2014). Sastre and Mullet (1992) posited adolescents begin to become aware of their career aspirations and interests as early as 14 years of age. Moreover, Super (1992) reported students in secondary schools are at the exploration stage where they start to make tentative choices about careers, including related skills development. Female students’ interactions with same-sex role models and peers can also influence their career aspirations (Kracke, 2002; The World Bank, 2009).

Field trips to agricultural research organizations, trade fairs, and universities should be incorporated into students’ YFC activities to provide opportunities to interact and network with professionals and peers who share similar interests (Mukembo et al., 2014, 2015). The development of social networks among youth and adults with similar career aspirations is one way females may become more attracted to careers in the agriculture sector (Kruijssen, 2009).

A need exists to promote awareness of the challenges females are likely to encounter in the agriculture sector, including giving special attention to potential solutions when providing them career guidance in high school. The challenges addressed may include increasing their access to resources such as land, overcoming discrimination at school or at work as advanced by male peers and supervisors, and mitigating prevailing cultural norms promulgated by community members. Promoting such awareness would better prepare female students to make properly informed decisions about how to address challenges encountered as they pursue agricultural interests and careers. This may help reduce the high attrition rate among females who pursue such careers and yield better returns on the investments made in building human capital for the agriculture sector (Hornbeck & Salamon, 1991; Mukembo et al., 2014; Nafukho et al., 2004; Schultz, 1972, 1981). Gender-based stereotypes associated with females pursuing careers in agriculture (Anderson, 1995; Kelsey, 2006), i.e., a sector traditionally dominated by males, are still prevalent and discourage females from becoming professional agriculturists. Therefore, more research should be conducted about the impact of subjective norms (Ajzen, 1991) on females pursuing careers in agriculture, especially in SSA. These investigations may involve a mixed methods research approach to triangulate and understand better the interplay of gender, agricultural careers, and socio-cultural norms. More research also should be done with females in other settings who experienced a similar phenomenon to compare their views to this study’s findings. Such could be useful in the formulation of future policy and practice.

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Capacity Development in Agricultural Education and training in Cambodia: A SWOT Analysis

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Abstract

This paper examines the current state of the agricultural education and training (AET) system in Cambodia and provides recommendations for Cambodian institutions and policymakers for enhancing the AET system. We conducted two assessment trips in June 2013 and January 2014 to analyze the state of the Cambodian AET system. Data were collected in 53 interviews and five focus groups using a modified-SWOT analysis framework. Stakeholder-identified strengths of the Cambodian AET system include the current political and economic stability of Cambodia, the young labor force, the increased educational enrollments, new agricultural education schools and curricula, good AET leadership, and the wide applicability of AET skillsets. Weaknesses of the Cambodian AET system include weak infrastructure, pedagogical stagnation, skills supply, the disconnect between the supply and workforce demand, and weak institutional administrative expertise. Meanwhile, threats to strengthening the Cambodian AET system include limited public investment, the gap between agriculture and education, low status of agriculture, and poor access to higher education. Recommendations for institutional capacity development in the Cambodian AET system include enhancing skill development and furthering links with NGOs and the private sector, while policy recommendations include welcoming prudent regional integration and enhancing investment across the whole AET system. Comparing our findings to other recent AET system studies indicates that Cambodia is facing similar challenges yet has its own unique path to forge when developing a cohesive AET system capacity-development strategy.

Keywords: Capacity development, Cambodia, Agricultural education and training, AET system, Human and institutional capacity
Introduction

Agriculture is the mainstay of the Cambodian economy, contributing 35% of the national GDP and providing two-thirds of the total workforce with their primary occupation (ADB, 2013; FAO, 2014). As a largely agrarian society, with 80% of the population living in rural areas and 85% engaged in agricultural production, development of the agricultural sector in Cambodia remains a priority to reduce poverty and improve food security (Kingdom of Cambodia, 2013a; USAID, n.d.). The World Bank estimated in 2012 that 17.7% of Cambodia’s population fell below the poverty line (at the time, 1.25 USD/day). Even though Cambodia has sustained an impressive annual economic growth rate of 7.3% since 1993, growth in the agricultural sector has lagged at an annual average of 4-5% in the past ten years (FAO, 2014). Furthermore, agricultural sector growth is inconsistent, and remains vulnerable to shocks, such as the September/October 2013 floods which set annual agricultural growth back to 1.8% (ADB, 2013).

Developing human and institutional capacity to meet the challenges of rural poverty and food insecurity after three decades of conflict, including the genocidal Khmer Rouge regime, requires an effective and resilient education system with a clear focus on agricultural education and training (AET). There is a growing demand for skilled labor in Cambodia to develop the economy, including the agricultural sector. However, only 41% of those under the age of 25 in Cambodia have completed lower secondary school, and those that do go on to complete higher education are still not well equipped to meet the demands of the workforce (Kingdom of Cambodia, 2013b).

The government of Cambodia has clearly expressed human and institutional capacity building and development of agricultural research and education as priorities in its national strategic frameworks (e.g., Kingdom of Cambodia, 2004, 2010). Despite this prioritization, there has been no in-depth analysis of the capacity-development needs in the Cambodian AET system. This paper uses a SWOT analysis framework to examine the strengths of, barriers to, and threats to the Cambodian AET system, concluding with opportunities for institutional and policy changes to improve the system’s performance.

Conceptual framework: capacity development and performance for AET

AET systems in low-income countries are frequently characterized as weak, ineffective and lacking in capacity. There are increasing calls for “capacity development” not only for these systems themselves, but also for generating sustainable economic growth, food security and poverty reduction in societies that are still heavily dependent upon agriculture. Yet, what is meant by “capacity development” and “capacity” for “AET systems”? We understand AET systems to incorporate all the stakeholders involved in formal agricultural education, ranging from basic/primary school level education through secondary, tertiary and technical and vocational institutions (TVET). The AET system also incorporates various actors that have an interest in AET institutions, their policies, their graduates, and their performance. These actors are not students or employees of an AET institution, but may work in government, non-governmental organizations (NGOs), industry, donor organizations and foreign institutions.

Most frequently, capacity development (CD) is seen as a process to achieve certain objectives. While the World Bank’s CD Results Framework proposes that CD is “a locally-driven process...to achieve a development goal” (Otoo,
Agapitova & Behrens, 2009), the United Nations (UN) provides a slightly more nuanced definition of CD as a transformative process achieving measurable development (UNDP, 2008). The UN framework portrays CD in three dimensions: individuals, organizations, and enabling environment (FAO, 2010; UNDP, 2008). For AET systems, this can be conceptualized as: 1) individuals: students, staff, teachers, faculty members, and all individual personnel; 2) organizations: primary, secondary and tertiary level institutions, including TVET; 3) enabling environment: international and domestic policy-makers/government ministries, industry, donors, NGOs. In this model, all three dimensions a) have influence on, and, b) are affected by each of the other dimensions. Although arguably rudimentary, this framework does highlight both internal and external stakeholders to a CD system.

However, both the World Bank and UN frameworks have emphasized capacity “building”, implying that they follow prescribed models for enhancing capacity, rather than capacity “development”, implying an organic process (Horton, 1999). Such models are potentially too rigid, lacking recognition of CD as a fluid and experimental learning process. As a result, more recently there have been increasing calls for focus on capacity “development”, and approaches that a) account for the complexity of capacity challenges and b) use holistic systems-thinking (van Deuren, 2013; Watson, 2010). Part of the complexity behind the term “capacity development” stems from the fact that it refers to capacity in the singular, whereas it is more appropriate to think of “capacities” that need to be systematically developed across all dimensions. These capacities include human, physical, financial, social/cultural, and political capitals. Meanwhile, systems-thinking is an appropriate approach for CD as it emphasizes not only improving the capacity of the parts (or dimensions) of a system but also enhancing the interaction of these parts (Jackson, 2003; Meadows, 2008).

In recent years, however, there is increasing acknowledgment that systems-thinking approaches to CD in AET must be coupled with performance improvement of these systems (Kelly & Palmucci, 2014; USAID, 2010; Watkins, West-Meiers & Song, 2013). For example, what good is it if financial investments in an AET system result in new laboratories being built, without the trained scientists and technicians to understand how to effectively use all the new tools at their disposal, the students to design research projects to utilize the lab, and the field space to replicate lab experiments under field conditions? Capacity development for AET thus must focus on measurable improvement in performance of the system that aligns the generation of a highly-skilled workforce with the current and future demands of the agricultural workforce.

As such, approaches to human and institutional capacity development (HICD) are increasingly borrowed from the performance improvement literature. Chevalier’s (2003) updated Behavioral Engineering Model (BEM), first described by Gilbert (1978), is perhaps the most widely used. This model provides a way to identify barriers to performance improvement of a system by evaluating two principal levels of factors – environmental and individual – and their subfactors. The updated BEM recognizes that, while individual factors (including an individual’s knowledge and training, capacity, and motives) are important, the environmental or institutional factors are perhaps the most pressing to address when trying to build systemic capacity. To help make this point, Chevalier quotes Rummler & Brache (1995), “If you pit a good performer against
a bad system, the system will win almost every time.”

Major international donors, like the United States Agency for International Development (USAID), have also referenced the updated BEM and put renewed emphasis on performance improvement as a key component of capacity development. This marks a transition away from donor approaches to CD in AET systems since the 1980s, which have focused on individual training as the prioritized method of CD. Indeed, USAID’s current focus on performance improvement coupled with systems-thinking approaches is somewhat reminiscent of the massive AET institutional capacity building programs undertaken by the agency in the 1960s and 70s, such as those between US land grant universities and universities in India (Goldsmith, 1988), which were attributed as significant to the progress of the Green Revolution in South Asia.

Cambodian context of conceptual framework

Research for this study was conducted under the HICD framework that is currently being used by USAID, as Cambodia is one of the priority countries under Feed the Future (FtF), the US government’s global hunger and food security initiative. Cambodia’s history since independence in 1953 has been ruptured by three decades of civil conflict in the second half of the 20th century; thus, capacity-development activities have scarcely been implemented or even possible (Chandler, 2007). The civil war that began in March 1970 led to a steady dismantling of Cambodian education systems, which accelerated under the Khmer Rouge (Ayres, 1999). The Khmer Rouge period also resulted in a systematic destruction of all types of capital within Cambodia’s AET system. Even though the Khmer Rouge rule of their “new Cambodia” lasted less than four years, development was set back in Cambodia by more than 20 years. Peace and stability since the end of the 20th century, however, have led to steady economic growth and the beginning of regional integration, with Cambodia accepted as the tenth member of ASEAN (The Association of Southeast Asian Nations) in 1999. Although Cambodia remains towards the bottom of the pile in the ASEAN network in terms of economic, educational and agricultural development, progress is being made in all spheres. But how far has Cambodia come in developing a more robust AET system to help meet its economic growth, poverty reduction, and food security needs?

Purpose and Objectives

The purposes of this paper are to understand the current state of the AET system in Cambodia and to provide recommendations for Cambodian institutions and policymakers for enhancing the AET system. There has been little published literature on AET in Cambodia, and what literature exists primarily focuses on either agricultural production or educational reforms (Ayres, 2000; Tan, 2007), with little focus on agriculture and education combined. How can the capacity of the agricultural sector in Cambodia be developed if so little is known about the agricultural education system in the country that trains the workforce?

The objectives of this paper are fourfold: 1) Identify strengths of the current Cambodian AET system, 2) Identify weaknesses currently preventing the improvement of the Cambodian AET system, 3) Identify threats to the future strengthening of the Cambodian AET system, and 4) Recommend opportunities for a) Cambodian AET institutions and for b) Cambodia national policy-makers to develop the AET system as an engine for
agricultural economic growth, food security, and poverty reduction.

**Methods**

Initial data on Cambodia’s AET system were collected through secondary sources prior to field research. Following this, we (the authors) conducted the in-country field assessment in two stages, with a 10-day preliminary data collection trip in June 2013, followed by a two-week assessment in January 2014. Based on our assumption that there are a select number of people who can articulate the issues in the Cambodian AET system, we used a purposeful (snowball) sampling method to identify key informants and groups of individuals to interview. This qualitative approach involved discussion-based interviews around guiding questions, which allowed respondents to drive the conversations to issues they deemed important and relevant, while also allowing respondents to uncover issues that we may not have thought important or known about before interviews or focus groups began.

Our preliminary trip enabled us to build trust and relationships with stakeholders, to validate and update information found in literature reviews, and to identify an AET network in-country. During this visit, we made contacts with several important local institutions, and conducted 15 key informant interviews and one focus group. Having compiled a full list of AET stakeholders to visit, our second trip to Cambodia involved the completion of a further 38 key informant interviews with employees at a range of institutions, including various government ministries, universities, donor agencies, NGOs, and private agri-businesses. We conducted four focus groups with AET stakeholders including an NGO, a group of agricultural private sector employees, and current and recent graduates of AET institutions.

A modified-SWOT analysis was used to guide the interviews and focus groups, where respondents were asked to identify strengths, weaknesses, opportunities, and threats facing the Cambodian AET system. A SWOT analysis is a useful tool for improving decision-making in complex systems by compiling and organizing information (Helms & Nixon, 2010). SWOT is commonly used for assessing elements of agricultural education systems (e.g., Aiyelaagbe, Harris & Olowe, 2016; Tukundane et al., 2015; Alonge, 2006). However, we believe a SWOT analysis can also provide a holistic, system-wide overview, and in this context, we used SWOT components to represent both internal attributes (strengths and weaknesses related to individuals and organizations) and external factors (opportunities and threats facing individuals and organizations in the broader enabling environment context) of an AET system. We modified the SWOT because we found that, during interviews, respondents used the discussion of “opportunities” as a chance to once again discuss strengths as well as highlight recommendations for AET system improvements. In the organization of this paper, we therefore present the strengths, weaknesses, and threats before our discussion of the opportunities/recommendations.

Upon return to the US, data collected from the interviews and focus groups were analyzed using content analysis in order to draw out and categorize the most important findings. We took the following steps to conduct our content analysis: i) triangulated data gathered through multiple sources and different collection methods; ii) ensured validity of any primary data gathered when using a Khmer translator; iii) counted words and phrases from interview and focus group notes to identify which issues were highlighted most often; iv) identified
instances when issues were stressed, highlighted or prioritized by respondents; v) categorized notes for data reduction, especially when respondents identified interrelated and similar issues; and vi) confirming lists of issues with the literature, each other, and with Cambodian counterparts. Use of multiple data collection methods, including interview and focus groups, triangulation of field data with literature findings, and repeated visits by the research team to Cambodia ensured trustworthiness for the data collection and analysis. The findings presented in this paper represent the interview and focus group data, supported by secondary sources.

Subjectivity statement and limitations
The research team was led by US-based researchers, as this was funded under a USAID grant from Washington DC, to assess AET capacity in Cambodia, not tied to one or more specific Cambodian institutions. We recognize that US-based researchers potentially view AET capacity through “Western” epistemological standpoints. We did not have any Cambodian researchers on our team, to eliminate bias from any one particular institutional standpoint from within Cambodia. To offset bias, all interviews were conducted in English, and only when necessary did we request Cambodian (Khmer) translators to help clarify points of discussion. While our guided questions led respondents to articulate issues under a SWOT framework, there were issues that were discussed by respondents across multiple sections of the SWOT framework, e.g., issues that could be viewed both as a weakness and an opportunity. We had to carefully review respondents’ answers and clarify these issues for accurate reporting of findings under the SWOT framework.

Findings

Strengths
(1) Stability encourages increased investment. Cambodia is witnessing increasing levels of Foreign Direct Investment (FDI) and Overseas Development Assistance (ODA) across all sectors due to both relative political stability and country needs classifications (e.g., its designation in 2010 as a US government FtF country; listed as 104th in world GDP rankings). This increasing external investment is providing opportunities for CD activities in Cambodia, some of which are targeting agricultural education. One example is the Food Security III program, under FtF, which provides funding for CD activities including short course training in food security project impact and evaluation (Michigan State University, n.d.).

(2) Young labor force. Although the profound impacts of the Khmer Rouge genocide and decades of conflict are still being felt, the burgeoning youthful population in Cambodia provides a human influx that can potentially be harnessed for AET human CD. Sixty percent of Cambodia’s population is under 30 years old, while 32% of individuals are between 11 and 24 years of age (PRB, 2013). This age distribution presents a large pool of potential agricultural workers to be trained across AET sub-sectors. The youthful population provides a real opportunity for Cambodians to be trained in agricultural disciplines and boost agricultural economic growth.

(3) Increased educational enrollments. Enrollment rates at Cambodian universities are rising, with an estimated 168,000 students enrolled in 2009, a 16-fold increase from 1997 estimates (Buntong & Chea, 2014). At the Royal University of Agriculture (RUA), Cambodia’s only higher education institution exclusively dedicated to the agricultural sciences, student enrollment has quadrupled since 2007-08,
with almost 2,000 students currently enrolled (Buntong & Chea, 2014). The location of RUA’s campus, on the outskirts of Phnom Penh, enables the institution to draw students from both urban and rural backgrounds. This is particularly important since Cambodia continues to experience rapid urban growth (around 3% /year), outpacing population growth rates in the country (World Bank, n.d.). Furthermore, respondents noted (though no accurate data were provided) that a high percentage of AET graduates find employment within government or NGOs, helping to provide greater access to job opportunities for future graduates of the AET system.

(4) New agricultural education schools and curricula. Beyond RUA, other schools are beginning to provide agricultural education. One example is the University of Battambang, which has completed major infrastructural developments to provide up-to-date facilities for agricultural education, including a new tissue culture laboratory, greenhouse, and classroom space. Agricultural education can also increasingly be sought through vocational schools, short-term programs, and farmer field schools.

(5) Leadership of AET. Many high-ranking university administrators have dual roles in various ministries that strengthen information channels and partnerships. Respondents also noted that governmental leadership, administrators, faculty, and students have a very high level of energy and enthusiasm for addressing Cambodia’s pressing AET needs. Several faculty at RUA have experience working with donors and other collaborators to develop AET capacity, particularly through certificate programs and short-term workshops.

(6) AET skillsets applicable country-wide. Respondents noted that as Cambodia has a small geographical area, AET skillsets are typically applicable in most regions of the country. Khmer is spoken throughout Cambodia, also ensuring that AET skills developed for the workforce can be applicable countrywide. Respondents also thought that Cambodia had fewer agroecological zones than neighboring countries. While this is true in comparison to Vietnam (which has nine agro-eco zones), Cambodia actually has the same number of agro-eco zones as Thailand (four) (UNDP, 2011). As Cambodia’s agro-ecological zones have overlapping characteristics with its neighbors, there may be opportunity to apply AET skillsets region-wide.

Weaknesses

(1) Weak infrastructure. Infrastructure upgrades related to a variety of AET programs remain a significant challenge. Several facilities need new equipment, and staff members need to be trained on how to properly utilize new equipment and integrate the technology into the curriculum. Many respondents indicated how dependent Cambodian AET programs were on donor projects for the supply of modern equipment. There is also a lack of experiential learning venues (e.g., well-equipped labs, field research sites) to provide spaces for hands-on learning. Furthermore, where off-campus research facilities, e.g., field research sites, do exist, they are often connected by weak public infrastructure including road access and power grids. This makes it difficult to provide students and faculty with the opportunities to rigorously test theoretical principles learned in the classroom in applied spaces.

(2) Pedagogical stagnation. Throughout the Cambodian AET system, there is an emphasis on rote learning and a lack of experiential education opportunities. Furthermore, pedagogical stagnation continues as the majority of junior faculty are recent graduates from bachelor’s programs and due to high turnover rates of
faculty due to low salary caps. Faculty members need training on how to educate students to be more capable of critical thinking and innovation. Different styles of learning need to be introduced, which will break the current emphasis on memorization of facts. Faculty members need to be given space and opportunity by their institution’s higher administration and by government ministries to explore ways for creative engagement in and beyond the classroom.

(3) Skills supply. The most significant barrier noted by students and employers was the multifaceted issue of skills supply. First, there is a lack of agricultural education throughout the educational pipeline, both in formal education through primary and secondary schools, and in informal settings through community development activities. Thus, students who enter technical and vocational education and training (TVET) or universities are often underprepared in terms of their technical knowledge in agricultural disciplines. In addition, there is a lack of development of soft skills, such as leadership, communication, management, analytical thinking, and decision-making. Agricultural employers interviewed especially noted that finding suitable candidates with a combination of well-developed technical knowledge and soft skills is difficult. This finding was confirmed by a study that highlighted that 15.5% of Cambodian firms and 22% of foreign firms reported skills as a major constraint to growth (World Bank, 2012). Although there are increasing calls for employers to look beyond universities and instead to TVET institutions as the suppliers of these soft skills (Sopheap, 2012), these institutions are underutilized, undervalued and suffer from low attendance and poor-quality resources. Cambodia has one of the smallest shares of students currently enrolled in TVET (1%) both regionally (World Bank, 2012) and compared to other FtF countries (JICA, 2007).

Another important component of the skills supply barrier is the need for updated curricula. Cambodian educational institutions have been run under several different systems in the past (Russian, Japanese, French, Khmer, etc.), so curricula are disjointed and outdated. Additionally, weak English skills among most students limit their employment options. Teachers, researchers and administrators in the AET system may also have limited English skills, hampering the ability of these institutions to develop fluent English-speaking graduates. In order to a) be able to work across borders and b) be on a level-playing field with graduates from other ASEAN countries, Cambodian graduates will need to meet standard language (ASEAN's current working language is English) and education requirements (ASEAN, 2012).

(4) Disconnect between skills supply and workforce demand. Linked to the shortfall in skills supply, agricultural employers noted that they cannot find Cambodians with the skills they need for the jobs they have. Types of skills reported included not only a high level of technical expertise in specific disciplines, but also “soft” skills such as those mentioned under (3) above. This is partly due to the low numbers of degree graduates in agricultural disciplines, but respondents noted that it was more linked to the mismatch between skill provision in the formal AET system and the skills demanded by the workforce. For example, the Ministry of Agriculture, Forestry and Fisheries (MAFF) noted that extension workers need relevant, hands-on training, which is not currently provided by AET institutions, and both students and employers mentioned that on-the-job training is often more useful than school-based training. This barrier is reinforced by the dearth of certificate programs and
continuing education opportunities. Additionally, employers lack the means by which to communicate their desires for certain skills in successful future job candidates; currently, there is no labor market information system to survey labor market demand and connect it to supply.

(5) Weak institutional administrative expertise. Respondents noted that AET institutions do not have mechanisms in place to administer external funding opportunities. For example, it is not standard for institutions to take administrative overhead out of incoming university grants. Many Cambodian universities are currently engaged with donor organizations, receiving funds from outside sources such as USAID, JICA, etc. However, an increase in the number of opportunities for external engagement is limited by the weak administrative capacity of Cambodian institutions to efficiently manage extramural funding.

Threats

(1) Limited public investment in AET. Respondents overwhelmingly highlighted the continual underinvestment in AET by the government as a serious barrier to strengthening the AET system in Cambodia. Public investment in education was 20% of the national budget in the 1960s, when Cambodia was building its university infrastructure (Duggan, 1997). Though official data are lacking, there was a complete tear-down (physically and administratively) of educational infrastructure throughout the 1970s, and educational investment was largely ignored by the ruling Vietnamese from 1979. As a result, public investment in education had declined to 7% by 1999. This investment is still yet to return to 1960s levels, with current estimates at approximately 13-14% (ADB, 2013; World Bank, 2012). Meanwhile, Cambodian government spending on agriculture remains under 2% of GDP, and the majority is spent on irrigation and rural roads. Interestingly, a World Bank study into Cambodian government spending highlighted the prioritization of the agriculture sector, yet failed to mention anything about the role of AET in ensuring sustainable agricultural economic growth (World Bank, 2011).

(2) Gap between agriculture and education. Twelve governmental ministries and two institutions oversee the 97 higher education institutions (HEIs) in Cambodia (Buntong & Chea, 2014). The government ministry structure appears to struggle to coordinate across ministries. Of particular importance to the functioning of AET systems is the gap between the Ministry of Education, Youth and Sport (MOEYS) and MAFF. HEIs often do not communicate effectively and remain siloed, in part due to their differing affiliations. In particular, the gap between agriculture and education is entrenched as RUA, under MAFF, lacks strong ties to MOEYS and its affiliated HEIs.

(3) Low status of agriculture. Lack of interest in AET by young people causes significant brain drain to other, more lucrative industries, such as information technology. Only 20% of graduating secondary seniors base their decision on what to study on the labor market, while 70% followed their parents’ advice (ILO, 2008). As a result, high quality students are not entering agricultural disciplines. Additionally, salaries in the traditional agricultural sector remain comparatively low, further reducing the status of agriculture as a meaningful and profitable line of work.

(4) Access to agricultural higher education. Enrollment rates in agricultural higher education in Cambodia are still comparatively low regionally. The national higher education enrollment rate in
Cambodia was 11% in 2008, which is much lower than Thailand (32%) and the Philippines (29%) (World Bank, 2010). Additionally, only 2.3% of all bachelor’s students in Cambodia are studying in the agricultural sciences (World Bank, 2012). The same pattern exists in TVET: the share of upper-secondary and tertiary students enrolled in TVET in Cambodia is 6%, one-third that of Vietnam (World Bank, 2012). There is also a notable gender access gap to higher education in general, and AET in particular. For example, the latest enrollment figures for RUA indicate that the share of female students is only 27% (Buntong & Chea, 2014).

**Recommendations for AET system capacity development in Cambodia**

There is an urgent need for revitalizing the Cambodian AET system in strategic new directions. Four recommendations emerged from interviews and focus groups as the priorities for capacity development in the Cambodian AET system. These recommendations include two opportunities for AET institutions to develop their capacity and two implications for policymakers for strengthening the AET system.

**Implications for AET institutions**

(1) **Enhance skill development and reduce skill gap.** There is an urgent need to build transferable skills in AET graduates in order to develop a workforce that is creative, flexible and innovative for agricultural growth and development. This starts early: the introduction of agricultural education as early as primary school should be considered, while there is also potential to introduce agricultural education across Cambodia at the secondary school level through the “life-skills” curricula currently offered by some schools.

There is a particular need to focus on CD for value chains, and to reform the image of agriculture as simply “on-farm production”. This will help to break down the silos between agriculture and education, and between agricultural disciplines and other subjects of study. Student skills can be developed through updating and generating interdisciplinary curricula that address agricultural value chains from producer to consumer, including topics such as business development, food processing, environmental management, and biotechnology. These curricula will provide graduates with broadened understandings of agriculture and increased synergies with other disciplines (and hopefully will attract youth to the agricultural sector), while the inclusion of new topics will ensure that students maintain depth in technical disciplines. To upgrade these curricula, financial resources should be applied not only to materials (e.g., enhanced staff and student access to the newest books and journals), but also to training of staff in innovative, experiential teaching approaches. Such approaches might include hands-on learning and the application of participatory methods to support a shift from teacher-centered to student-centered learning environments (Navarro, 2009). Increasing offerings of English classes and developing curricula in English are also important to prepare graduates to engage internationally and will enhance their employability.

There is a need to consider AET programming beyond formal university degrees to engage a broader client base and fulfill a range of agricultural workforce demands. This could take a variety of programming forms, harnessing the advances in information and communications technologies, and include certificates, distance education (e.g., Grunfeld & Ng, 2013), and short-term training courses, on a variety of topics. These are especially important for skill
development in particular niche opportunities, and for professionals who need rapid skill development for the workplace. One opportunity is increasing engagement with TVET institutions that attract both experienced and young farmers as well as other youth and those already employed in the sector. This would allow education to be demand-driven and let the trainees make themselves increasingly valuable to employers. Another opportunity is training administrative staff at AET institutions in management of external funding to improve their competitiveness and ability to effectively partner with international institutions.

(2) Further links with NGOs and the private sector. Through increased connections with NGOs and the private sector, AET institutions can move from a supply-driven model to a more viable demand-driven model by teaching skills based on workforce and market demand. Increased linkages with these groups would attract younger generations to agricultural disciplines, due to the enhanced potential of employment following education and training. Increased linkages between technical and theoretical classroom-based learning and market innovation and business development through hands-on learning opportunities are especially important. One way this can be achieved is through public-private partnerships (PPP); for example, food product and agricultural input companies in Cambodia could provide paid internship opportunities for interested students on a competitive scholarship basis. These internships may lead to future job opportunities and facilitate direct linkages between AET institutions and private companies. One example of a PPP is between GIZ and East-West Seed (Keo, Acosta, Sayoc, & Morris, 2012), that has developed linkages with a variety of AET institutions to provide training for both students and farmers.

Implications for Policy

(1) Welcome prudent regional integration. As the ASEAN Economic Community becomes a reality, Cambodia’s economy is set to become further integrated with economies throughout Southeast Asia. With integration, Cambodia is forecast to see the largest economic growth in region, with increased wages and increased employment opportunities, particularly in the informal sector (Plummer, Petri & Zhai, 2014). Prudent regional integration could also bring significant gains for the Cambodian AET system. ASEAN integration may lead to greater opportunities for AET exchanges: regional technical experts could train students and teachers at Cambodian institutions, and Cambodian AET teachers and researchers could train at regional universities for higher degrees. Improved links with regional universities could also build capacity in research methods and extension expertise. In addition, an improved AET system that produces skilled laborers for critical food sectors would facilitate Cambodia’s ability to compete in regional agricultural markets. However, ASEAN integration may present greater opportunity for skilled Cambodians to find employment in other countries, which could promote brain drain from Cambodia. Cambodia will also need to adapt to ASEAN university standards, which will not only push present capacity of Cambodian AET programs beyond their capabilities, but also put graduating students in direct competition with more advanced ASEAN students.

(2) Enhance investment across the whole AET system. Cambodian government ministries need to work with private sector partners and AET institutions to leverage increasing foreign investment to develop
AET system capacity. Regional players in the East account for the largest share of FDI into Cambodia, much of which is invested into the agricultural sector. Yet, Cambodia must also look to partners worldwide. One example is the agricultural investment in Cambodia through the United States FtF initiative and the HARVEST program (Lesnick, 2013). The Cambodian government and AET stakeholders need to further discuss ways in which such foreign investment can be used not only for agricultural sector development, but more specifically AET system CD. Despite this increased foreign investment, any CD in the Cambodian AET system is dependent upon increased commitment to AET investment from the Cambodian government itself. This involves increased financial commitment to both developing physical infrastructure in the AET system, and also to enhancing access to, and quantity and quality of AET programming. This needs to be complemented by improved coordination between government ministries that oversee the AET system, notably MAFF and MOEYS, and a commitment to bridge the gap between agriculture and education.

**How does Cambodia compare to other AET systems?**

Cambodia is a relatively small country, with a limited number of AET institutions. While we feel we were adequately able to analyze Cambodia’s AET system under this research, conducting such an analysis in many other low and middle income countries may not be possible due to their larger geographic size and/or greater number of AET institutions. However, there are some other recent examples of AET system analysis that exist and are worth noting when considering how Cambodia’s AET system compares to other developing countries.

A country-wide study of Thailand’s AET system uncovered some similarities to and differences from Cambodia’s AET system (Traimongkolkul & Tanpichai, 2005). The study addressed AET strengths and weaknesses in Thailand at three levels: basic education, vocational programming, and higher education. The authors found some similar constraints to be addressed, including the need for updated curricula and resources for agricultural education; the need to recruit and retain young people in agricultural studies; and the need for increased budgets and investments. Ultimately, Traimongkolkul & Tanpichai (2005) proposed the formation of a task force composed of agriculture and education professionals to create a united plan and direction for the nation's AET system, and a suite of recommendations to strengthen all levels of AET while also considering how to better link formal and non-formal education in agriculture. Little was mentioned, however, about the need for regional integration. Much of this may be due to the comparative strength, robustness and diversity of the Thai AET system in comparison to Cambodia. Cambodia, being a smaller neighbor with a weaker AET system, evidently has much to gain from an outward-looking regional focus to match current ASEAN levels and demands.

In an analysis of post-secondary agricultural education and training (PSAET) institutional challenges across sub-Saharan Africa, Rivera & Davis (2008) highlighted the critical concept of workforce development. They also highlighted the need to connect AET supply to workforce demand by addressing structural gaps in the current AET system. Meanwhile, in another study on strengthening AET system capacity in sub-Saharan Africa, Spielman, Ekboir, Davis, & Ochieng (2008) stress the importance of developing innovative capabilities of AET organizations and
professionals, changing organizational cultures, behaviors and incentives, and building innovation networks and linkages. In particular, they note the importance of aligning the mandates of AET institutions with national development aspirations (i.e. tying the training of individuals to the workforce needs of the nation), and incentivizing the linkages between AET institutions and diverse user communities, as well as the private sector. All of these factors resonate well with our findings in Cambodia, and suggest that many of the challenges facing the Cambodian AET are similar to AET challenges in other low-income countries.

**Recommendations for further analysis**

There needs to be a comprehensive approach to CD that leads to performance development, bridging the gap between theory and practice, to make recommendations at both the policy and institutional level. There is increasing focus (especially in international development) on understanding HICD models that identify best practices for CD from performance models to improve implementation (Lechtenburg, Ayeni, Christy & Kramer-Leblanc, 2014).

The assessment we conducted was just one snapshot in time. Continued assessment of needs and opportunities for reforming AET programs and institutions will go a long way toward developing lasting human and institutional capacity. It is important to incorporate adaptive learning and management into ongoing capacity-development strategies. It is especially critical to simultaneously develop capacity to monitor and evaluate targets for performance improvement over time, as performance improvement in coordination with local stakeholders is an integral part of capacity development for AET systems overall in low and middle income countries.

As such, an appropriate CD approach for Cambodia’s AET system must be developed together with the development of tools and metrics that can demonstrate whether CD does in fact lead to improved performance and lasting impact. Future studies could investigate appropriate benchmarks for performance monitoring and measurement for capacity development -- and capacity development for performance monitoring and evaluation -- in Cambodia and elsewhere.

The possibility of going beyond our basic analysis to include the application and integration of ranking, scoring or weighting assets to prioritize strengths, needs, and opportunities is also a consideration for future research. This would be of particular benefit to policy-makers, as it would help to identify areas of greatest opportunity and may help officials make strategic decisions that are high impact, while also considering resource limitations.

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International Journal of Educational Development, 40, 134-144.


Acknowledgements

This work was made possible by the United States Agency for International Development (USAID) and the generous support of the American people through USAID Cooperative Agreement No. AID-OAA-L-12-00002.
Farm Operations and Injury Risks to Children in Cocoa Households in the Western Region of Ghana: Implications for Extension Education

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Abstract
Cocoa remains the most important cash crop in Ghana, with the Western Region being the leading producer. More recently, concerns have been raised about ethical cocoa production, especially regarding child labour. Drawing on historical sources and a survey, the research assessed the injury risks of children in cocoa farming in the Western Region of Ghana and its implications for extension education. The study concludes that cocoa farm households in Ghana, typically in Western Region, engage children in the households in almost all aspects of cocoa production operations as a way of socializing them into the family cocoa production business – a complex and socially tolerable practice in Ghana. The extent of engagement however, is low across the operations. The operations engaged by the children are generally repetitive and include carrying loads, land preparation, planting, fertilizer application, harvesting, and breaking cocoa pods. More importantly, the study concludes that cocoa farmers are more at risk to injuries caused by repetitive strain, and lifting and carrying of loads, which are the work normally done by children. Nonetheless, the focus of extension education in Ghana has been on adult farmers in design and content. To effectively manage the risk associated with this complex phenomenon, the study emphasized the need for a holistic extension education that includes child-sensitive labour practices in cocoa production, focusing on the entire farm household. This will best empower cocoa households to ethically and health-wise socialize children as part of a livelihood system for sustainable cocoa production.

Keywords: Cocoa production, child labour, Extension education, Ghana, injury risk.
Introduction

Cocoa is the most important cash crop in Ghana, produced by over 800,000 smallholder farm families in six out of the ten administrative regions in the country, for more than 60 years (Hanson, 2007). For these smallholder cocoa farmers, cocoa accounts for over 67% of household income (Kolavalli & Vigneri, 2011). Most of the farms belong to individuals or families who transfer them from one generation to another to ensure financial security and peace of mind for all involved. These farmers or those they employ to work on the farms (caretakers) are mostly without formal education. In the rural areas of Ghana where cocoa is grown, the smooth transfer of cocoa farms from one generation to the other is done through the socialisation of members in cocoa production from early childhood to adulthood through in formal education (apprenticeship). Besides, adult cocoa farmers learn from each other, and from public and private cocoa extension workers through non-formal education. Thus, growing cocoa in Ghana involves adults and children. This context is not fully researched and understood and has thus, raised some child-labour concern in the Ghanaian cocoa industry in recent times.

As outlined in the Children’s Act, 1998 (Act 560) of Ghana, persons below 18 years, irrespective of how big or small they look, must be protected from child labour (Government of Ghana [GoG], 1998). By this Act, child labour is work performed by a person below the age of 18 years, which deprives the person of the basic human rights, and is abusive, hazardous, exploitative and harmful to the health, safety, moral attitude and development of the child. It includes work that denies children education or does not allow them to benefit fully from school, by way of attempting to combine school with heavy work or working for long hours. A concept understood by most rural cocoa farmers in Ghana is that childhood is a distinct stage of life requiring a tailored set of educational experience (socialisation) relevant to the world that the child will experience as an adult (Bastable&Dart, 2008). Apart from Ghana and other developing countries, many children across the world work at home to help parents with household chores and family economic activity as part of the socialisation process (Edmonds, 2008). The involvement of children in cocoa production by cocoa farm families has been a normal practice in Ghana for ages.

Research in Africa, however, shows that cocoa production has numerous health and safety risks. The International Institute of Tropical Agriculture (IITA) (2009) reported that weeding is one of the most injurious activities in cocoa farming. Cocoa production by its nature involves a high amount of manual labour involving the use of tools such as machetes, axes, harvesting hooks, pruners, ladders and chain saws which pose injury risks that may result in cuts, bruises and broken bones (Bosompem & Mensah, 2012). The nature of the cocoa farming system in Ghana, as described, suggests that people (adults and children) involved in cocoa farming are exposed to injury or health risks. This is an issue that can partly be addressed by extension effort to eliminate or reduce the health risks for sustainable cocoa production in Ghana. But currently, there is very little information on activities performed by children in cocoa farm households and the risk associated with them, apart from the sensational child labour reports on Ghana and Côte d'Ivoire which raised some serious child labour issues in cocoa farming in the two countries (Tulane University, 2011). Other works have focused on the various hazards and injuries associated with cocoa farm operations in general (Bosompen & Mensah, 2012; International Institute of Tropical Agriculture (IITA), 2009; Muilerman, 2013; Mull & Kirknorn, 2005).
In spite of the growing concern of children’s involvement in cocoa farming as earlier mentioned, and the possible negative effect it could have on their education if not managed, the Ghanaian cocoa extension system is yet to fully grasp the dynamics of the phenomenon and to comprehensively deal with it within its strategic youth in cocoa production agenda. The focus of cocoa extension over the years has been on adult farmers. In addition, the Ghanaian basic education system has not laid emphasis on Agricultural Science education, which is expected to prepare the youth into taking up farming as a vocation. Currently, Agricultural Science is no longer a teaching subject at the basic education level in Ghana, despite the critical economic role agriculture play in Ghana. The Agricultural Science subject since 2008 has been made part of an Integrated Science subject, with limited topics on agriculture. Besides, there are limited facilities (e.g. model farms, laboratories) for teaching and practical work of Agricultural Science at the basic and secondary education levels in the country. The recognition that children are engaged in cocoa production and thus subject to injury, together with the growing concern for child-sensitive labour practices and targeting of the youth for sustainable cocoa production have called for the need to assess these parameter and incorporate them into cocoa extension programming.

**The Purpose of the Study**

This paper discusses the injury risks of farm households in the Western Region of Ghana focusing on children or wards who are members of the household – not as hired labour. The specific objectives are to: 1) describe the cocoa farm operations that children in cocoa farm households are involved, 2) assess the injury risks associated with the operations, and 3) provide some suggestions for improving cocoa extension education in Ghana.

**Research Methods**

The Western Region was chosen for the study as it is the largest cocoa producer in Ghana (World Bank, 2011). The research data was collected using quantitative and qualitative methods. From a supervised cross-sectional survey, 398 randomly sampled cocoa farm households, in the Western Region of Ghana, represented by household heads were used for the research. The assumption is that a household head oversees home management, which include division of labour and health of the family, and is thus, in a best position to give information on children in the household. The sampled household heads (farmers) were drawn from an estimated 92,639 farm families in the Region based on the proportional sampling technique, in 4 randomly selected (out of 13) districts. These include Sefwi Akontombra (75), Juaboso (101), Asankragwa (146) and Wassa Akropong (76), all in the Western Region of Ghana. Structured interview schedule was used in the collection of the survey data. This was pre-tested for reliability on the Likert-type scale questions. The Cronbach’s alpha coefficient value calculated based on 30 selected farm household heads in the study area was 0.78. The farmers answered questions on the type of farm activities they make children undertake, the frequency of injury occurring with specific activities, and the consequences or severity of the injury.

The qualitative data was based on personal interviews of 12 community (field-level) extension agents from the selected districts to understand how the extension system is responding to the involvement of children in cocoa production in their operational areas in the Region. The author’s own work experience and interviews with farming groups and extension agents as an agricultural extension educator for over 15 years, and engagement with the Ghana
Cocoa Board for over 5 years as extension consultant in the Division of Cocoa Health and Extension also provided some insight into the phenomenon and its implications to extension education in Ghana. As such, the study drew on multiple sources of information (data triangulation) from interviews, documents, personal observations and different stakeholders (extension agents, farmers and policy makers) to ensure the validity of the results. Further, the informants were provided with summaries of the interviews to check the data and the interpretations to improve accuracy of the findings. All respondents in the study were also assured of confidentiality and anonymity.

Descriptive statistics were used to analyse and present the quantitative data. Based on a risk assessment model adapted from the Government of Southern Australia (Ogoe, 2015; Table 1), the injury risks in cocoa farming were rationalised into various risk levels as low, medium, high and extreme. These were determined, based on frequency of occurrence of an injury and the level of severity. Low level of risk means minimal risks that are unlikely to occur; medium represents some risk hazards that occur occasionally; high level means serious risks that occur frequently; and extreme level of risks mean catastrophic and critical injuries/ailments/disorders that occur frequently. The qualitative data collected were summarised to provide a logical explanation to meet the research objectives.

<table>
<thead>
<tr>
<th>Consequences/Severity</th>
<th>Insignificant: Dealt with by in-house first aid, etc.</th>
<th>Minor: Medical help: Treatment by medical professional/hospital outpatient, etc.</th>
<th>Moderate: Significant non-permanent injury, Overnight hospitalisation (in-patient)</th>
<th>Major: Extensive permanent injury (e.g. loss of finger/s) Extended hospitalisation</th>
<th>Catastrophic: Death. Permanent disabling injury (e.g. blindness, loss of hand/s, quadriplegia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent: When an injury has occurred 10 times or more to a farm worker</td>
<td>High</td>
<td>High</td>
<td>Extreme</td>
<td>Extreme</td>
<td>Extreme</td>
</tr>
<tr>
<td>Occasional: When an injury has occurred 5 to 9 times to a farm worker</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Extreme</td>
<td>Extreme</td>
</tr>
<tr>
<td>Seldom: When an injury has occurred 2 to 4 times to a farm worker</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Extreme</td>
</tr>
<tr>
<td>Rare: When an injury has occurred 1 to 2 times to a farm worker.</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Figure 1. Risk Matrix Template for Determining the Levels of Risk of Cocoa Farmer
Results and Discussion

As smallholder producers, most of the farmers had an average farm size of 3.3 hectares, with almost half of them (43%) operating on less than 2 hectares and using mainly family labour including their children and wards who are members of the household. The estimated average annual yield per hectare in the study area was 463 kg, slightly higher than the reported 389 kg by Hainmueller, Hiscox and Tampe (2011) for the Western Region. The average household size of the sampled farmers was eight, also higher than the average (4.5) for the Region (Ghana Statistical Service, 2013). The Western Region has a population of 2,376,021, with children (those less than 18 years) constituting about 45.35%.

Cocoa farm operations by children and adults

Table 2 shows the type of cocoa production activities that children are engaged in and the percentage of cocoa farm households that are involved in the practice. From the study, it was evident that all farm households engage children in one form of cocoa farm operation or the other as part of their training as household members. The extent of involvement by percentage of households engaging children is however, low – ranging from 0 to 24.42% for the various operations. The operations included land preparation, planting, farm maintenance and sanitation, harvesting, post-harvest handling, and others including carrying of load to and from farm. The practice of engaging children in farming is not unusual (Finnegan, 2007; GSS, 2008; West Africa Cocoa and Commercial Agriculture, Project (WACAP), 2003). A cocoa labour survey in Ghana found about 50% of children of cocoa farm households engaged in one or more cocoa farming operations, with most of them being males (GSS, 2008). Berlan (2004) gave even a higher percentage (95%) of children involvement in cocoa farming activities. According to WACAP (2003), about 14% of labour on cocoa farms in Ghana is supplied by children. For Mull and Kirknorn (2005), many of these children are less than 14 years of old.

The predominant cocoa farming operations in which most households engage children include carrying of seedling, water, cocoa beans, fuel wood, and food stuff; land preparation, including initial clearing, brushing and weeding; planting of cocoa seedlings; fertilizer application; harvesting of cocoa; and gathering and breaking of cocoa pods (Table 2). The highest engagement of children by the household was in planting and harvesting/postharvest activities (11.68% and 13.05%) respectively. Generally, these activities (planting, harvesting and fertilizer application) are repetitive and can be stressful and injurious when not supervised by adults. Few households engage children in the mixing (0.7%) and spraying of agro-chemicals (1.36%), and the cleaning up of spraying equipment after use (2.28%).

Interaction with cocoa farmers in different parts of Ghana over the years shows that farmers do not necessarily regard the mere involvement of children in cocoa farming as child labour. They consider the practice as necessary part of children’s upbringing in cocoa farm households. Besides, the farmers indicated that involvement of children in hazardous farm activities is unacceptable, although it cannot be ruled out as absent in Ghana. There have been reported cases of child labour, slavery and trafficking in the cocoa industry in West Africa, including Ghana by the International Programme on the Elimination of Child Labour (2005) and Tulane University (2011). The current research focused on children who are
members of the household and play a supportive role not as hired labour.

Cocoa production, which has been the work of adults, demands substantial energy, experience and alertness, especially in handling agro-chemicals, heavy loads/equipment and sharp farm tools. In almost all the activities, there is more male child involvement than female, although the differences are comparable.
Table 2  
**Cocoa farm operations engaged in by children and adults in the study area**

<table>
<thead>
<tr>
<th>Farm operations</th>
<th>Children (%)</th>
<th>Adults (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Land preparation</td>
<td>1.52</td>
<td>1.34</td>
</tr>
<tr>
<td>Initial Land clearing</td>
<td>3.03</td>
<td>2.85</td>
</tr>
<tr>
<td>Felling and chopping of trees</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>Burning</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Stumping and debris gathering</td>
<td>2.17</td>
<td>1.63</td>
</tr>
<tr>
<td>Planting</td>
<td>6.14</td>
<td>5.54</td>
</tr>
<tr>
<td>Digging of holes for seedlings</td>
<td>5.35</td>
<td>4.26</td>
</tr>
<tr>
<td>Carrying or supply of seedlings</td>
<td>8.18</td>
<td>7.59</td>
</tr>
<tr>
<td>Planting of seeds or seedlings</td>
<td>4.88</td>
<td>4.76</td>
</tr>
<tr>
<td>Farm maintenance and sanitation</td>
<td>2.46</td>
<td>2.44</td>
</tr>
<tr>
<td>Brushing/Weeding</td>
<td>4.79</td>
<td>4.66</td>
</tr>
<tr>
<td>Fetching of water for spraying</td>
<td>12.21</td>
<td>12.21</td>
</tr>
<tr>
<td>Mixing and loading of agro-chemicals for spraying</td>
<td>0.47</td>
<td>0.23</td>
</tr>
<tr>
<td>Chemical application/spraying</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>Cleaning up of spraying equipment after use</td>
<td>1.37</td>
<td>0.91</td>
</tr>
<tr>
<td>Disposal of empty agrochemical containers</td>
<td>0.47</td>
<td>0.23</td>
</tr>
<tr>
<td>Storage of un-used/left-over agrochemicals</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pruning of cocoa trees</td>
<td>0.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Mistletoe control</td>
<td>0.23</td>
<td>0.46</td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>4.44</td>
<td>4.77</td>
</tr>
<tr>
<td>Harvesting and post-harvest handling</td>
<td>6.67</td>
<td>6.38</td>
</tr>
<tr>
<td>Harvesting of pods</td>
<td>4.18</td>
<td>3.68</td>
</tr>
<tr>
<td>Gathering of pods</td>
<td>10.05</td>
<td>9.93</td>
</tr>
<tr>
<td>Breaking of pods</td>
<td>9.22</td>
<td>9.44</td>
</tr>
<tr>
<td>Construction of drying patios</td>
<td>2.46</td>
<td>2.66</td>
</tr>
<tr>
<td>Carrying of fermented beans from farm to the house</td>
<td>9.50</td>
<td>9.26</td>
</tr>
<tr>
<td>Stirring of beans during drying</td>
<td>1.38</td>
<td>1.08</td>
</tr>
<tr>
<td>Bagging and carrying of beans to buying centres</td>
<td>7.41</td>
<td>5.90</td>
</tr>
<tr>
<td>Other activities</td>
<td>3.65</td>
<td>3.90</td>
</tr>
<tr>
<td>Sharpening/preparing tools and equipment for farm</td>
<td>1.27</td>
<td>0.85</td>
</tr>
<tr>
<td>Planting of intercrop/food crops</td>
<td>3.61</td>
<td>3.76</td>
</tr>
<tr>
<td>On-farm cooking for farmers</td>
<td>1.78</td>
<td>3.16</td>
</tr>
<tr>
<td>Maintaining food crops</td>
<td>1.82</td>
<td>1.82</td>
</tr>
<tr>
<td>Harvesting of food stuffs</td>
<td>5.39</td>
<td>5.09</td>
</tr>
<tr>
<td>Fetching of fuel wood</td>
<td>8.06</td>
<td>8.71</td>
</tr>
<tr>
<td>Carrying food stuffs and fuel wood home</td>
<td>10.51</td>
<td>11.19</td>
</tr>
<tr>
<td>Carrying farm tools and equipment to and from farm</td>
<td>2.74</td>
<td>2.56</td>
</tr>
</tbody>
</table>


**Level of risk to injuries in cocoa farming**

This section discusses the levels of risk of injuries in cocoa farming activities affecting farmers in the Western Region of Ghana in general. The farmers assessed the frequency of occurrence and severity of various injuries to in cocoa farming in the Region. The injuries were grouped into: 1) repetitive strain injuries, 2) injuries...
from lifting and carrying of loads, 3) injuries from sharp tools, 4) injuries from the environment, 5) agrochemical use injuries, 6) machinery injuries, and 7) injuries from falls from heights (Table 3). Computing from the Risk Matrix in Table 1, the results show a high perceived risk (Mean, 2.02; SD, 0.30) of injuries in cocoa farming, a finding well supported by Mull and Kirknorn (2005), IITA (2009), and Bosompem and Mensah (2012). The authors reported that cocoa farming is one of the most hazardous occupations in Ghana. The results of the study show significant differences among the risk levels based on the scale: Low (0.01 – 1.00), Moderate (1.01 – 2.00), High (2.01 – 3.00) and Extreme (3.01 – 4.00). The F-Value was higher than its critical value, an indication that the risk of injuries to the farmers is significantly (p<0.00) different from each other and that the observed different levels of injuries are not just by chance.

Table 3
Level of injury risk in cocoa farm operations

<table>
<thead>
<tr>
<th>Type of Injury</th>
<th>M</th>
<th>SD</th>
<th>Level of risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetitive strain injuries</td>
<td>2.45</td>
<td>0.15</td>
<td>High</td>
</tr>
<tr>
<td>Injuries from lifting and carrying of loads</td>
<td>2.20</td>
<td>0.34</td>
<td>High</td>
</tr>
<tr>
<td>Injuries from use of sharp tools</td>
<td>2.20</td>
<td>0.30</td>
<td>High</td>
</tr>
<tr>
<td>Injuries from the environment</td>
<td>2.10</td>
<td>0.45</td>
<td>High</td>
</tr>
<tr>
<td>Agrochemical injuries</td>
<td>1.86</td>
<td>0.28</td>
<td>Moderate</td>
</tr>
<tr>
<td>Machinery injuries</td>
<td>1.76</td>
<td>0.32</td>
<td>Moderate</td>
</tr>
<tr>
<td>Injuries from falls from heights</td>
<td>1.57</td>
<td>0.31</td>
<td>Moderate</td>
</tr>
<tr>
<td>Grand Mean/S.D./level</td>
<td>2.02</td>
<td>0.30</td>
<td>High</td>
</tr>
</tbody>
</table>

F-Value: 5.07;  P-value: 0.00; F-Critical: 2.34

Repetitive strain injuries including palm blisters, general body pains, neck muscle pain and injury to the lower back and waist, was the highest with high level of risk to cocoa farmers in the study area. This is followed by risk injuries from lifting and carrying of loads, risk injuries from use of sharp tools, and risk injuries from the environment. Most of the activities in cocoa farming are repeated over a long period usually with little rest, exposing farmers to repetitive strain injuries. Mull and Kirknorn (2005) and the IITA (2009) have reported the impact of repetitive strain injuries in cocoa farming in Ghana. This is more critical for the children, whose involvement tends to concentrate on repetitive activities including carrying of loads (seedling, water, cocoa beans, fuel wood, and food stuff), land preparation, planting, fertilizer application, and harvesting and breaking of cocoa pods. Given that farmers in developing countries are highly exposed to the risk of repetitive strain injuries including musculoskeletal disorders (Cowie et al., 2005; Donham & Thelin, 2006; Forastieri, 2001; Pyykkönen & Aherin, 2012), it is very important to supervise and protect these children, who are in their vulnerable stages of life.

The results showed that the risk of agrochemical injuries was moderate. Agrochemical injuries considered in this research include feeling of weakness, body itching, severe headache, excessive sweating, difficulty in sleeping, pain in the chest, feeling of dizziness, nausea and vomiting, restlessness, stomach ache, diarrhoea and collapse. It means the farmers perceived the preceding injuries to occur seldom or occasionally and their effects as non-permanent, and at worst requires an overnight hospitalisation. Two
possible reasons may account for the moderate risk of agrochemical injuries. The first is that agrochemical injuries take a relatively long time to manifest, and thus, may not be easily perceptible to the farmers. The second reason is that the extent of direct involvement in agrochemical spraying by farm families is reduced due to government supported programme called Cocoa Pests and Diseases Control Programme (CODAPEC). In the past 10 years, the CODAPEC has supported farmers with teams of experienced pesticide applicators including hired men and CODAPEC staff to apply pesticides on cocoa farms to enhance productivity (Baah, 2012). Besides, farmers continue to apply their own agro-chemicals to supplement what is provided by CODAPEC.

The finding that the risk of agrochemical injuries was moderate in the Western Region of Ghana does not support the view that cocoa farmers are highly exposed to risk of agrochemicals injuries, as reported in the literature (Bosompem & Mensah, 2012; IITA, 2009; Mull & Kirknorn, 2005; Sosan & Akingbohungbe, 2009). This is probably due to the declining involvement of farmers in pesticide application in Ghana as already highlighted. However, the fact that some farm families still spray their cocoa farms, supervise CODAPEC applicators and live in the environment where the sprayings are done still raise some concerns of risk of agrochemical injury (perceived as moderate), to the children involved because of their vulnerability, and the fact that agrochemical effects might take longer time to manifest. The effects may include respiratory disorders and cancers which were not considered in the research. As reported by Forastieri (2001), Finnegian (2007), and Sosan and Akingbohungbe (2009), agrochemical injuries may result in chronic diseases such as cancers and respiratory disorders in the long-term. This may take over 20 years to manifest (Sosan & Akingbohungbe, 2009). As discussed earlier in Table 2, some farm households engage children in chemical spraying (1.36%) and cleaning of spraying equipment after use (2.28%), something that can be managed holistically through extension education. The key point is that children must be protected as much as possible from agro-chemicals if they are to grow and mature properly to replace the ageing cocoa farmers in the Western Region of Ghana.

The involvement of children in some of the activities in cocoa farming – though on a limited scale – is disturbing because they do not have the necessary skills and capabilities to deal with the hazards associated with the activities, thus the high risk of injuries. The results showed that children were involved at varying levels in land clearing, felling and chopping, burning, agrochemical application and related activities, mistletoe control, plucking pods and breaking pods. The GSS (2008) report posit that some of the activities, such as land clearing, felling and chopping are laborious and may involve the use of dangerous tools; burning can lead to smoke inhalation, respiratory diseases, burns and even death; agrochemical-related activities such as the mixing and application of pesticides and fertilisers have implications on present and future health; mistletoe control which involves climbing cocoa trees increases the risk of fall and injury; plucking overhead cocoa pods with harvesting hooks predispose children to injury from falling blades as well as bring about neck and shoulder problems; and breaking pods, especially with a cutlass, can lead to accidental cuts with other complications such as haemorrhage and tetanus.

From the preceding discussion, it is apparent that the engagement of children in cocoa production as practiced in the Western Region, if not properly managed through extension education and supervised by adults, can lead to child labour issues, as pointed out by the Ministry of Manpower, Youth and
Employment (MMYE) (2008). According to the MMYE report, the main issue of child labour in Ghana’s cocoa sector is involvement of children in hazardous work including being present in the vicinity of pesticides application and carrying of heavy loads. Although the Children Act prescribes 18 years as the minimum age for engagement in hazardous work (GoG, 1998), experience over the years with cocoa farmers shows that enforcement mechanisms are weak and compounded because farmers are generally uninformed of the requirements of the Act – in the interest of the child whose livelihood, the farmers themselves, are seeking to secure.  

Conclusions and Implications

The study highlights the importance of defining Child Labour in the context of the kind of activities undertaken by the child and the risk involved – all in the best interests of the child which not surprisingly, includes sustainable production of cocoa by farm families – the very families of which the children are members. The study shows that cocoa production in the Western Region of Ghana, involves children but, to a limited extent. As part of the socialisation process, cocoa production households engage children generally in carrying of loads to and from farm, land preparation, planting, fertilizer application, harvesting, and gathering and breaking of cocoa pods. Notably, the study found that, farmers engaged in the above operations are at high risk to injuries, especially from repetitive strain, lifting and carrying of loads, sharp tools, and the nature of the environment. This pre-supposes that cocoa farm households in the Western Region engaging children in cocoa farming expose them to high injury risk if they are not properly equipped and supervised by adults.

For sustainable production of cocoa for generations in particularly the Western Region and Ghana in general, cocoa extension education must consider injury risk management and other child-sensitive farm practices. This is to protect children from potential long-term adverse health consequences and to attract their interest in to cocoa farming as future vocation. These considerations will imply the need for a more holistic and child-sensitive cocoa extension approach. This approach will require an increasing role of the extension system (private and public) to influence national policy towards agricultural education, and the provision of appropriate competencies needed by children to properly socialise them at little or no risk to take up agriculture (cocoa production) as vocation if they wish to do so.

The new extension strategy will require advocacy and lobbying for possible re-introduction of Agricultural Science in the curriculum of Ghanaian Junior High School to help the youth to understand the basic principles of farming which include cocoa production. Furthermore, through collaboration, facilitation and training using various methods including the use of school gardens, agricultural shows and clubs, farmer learning groups and sensitisation campaigns, the extension system in Ghana can support cocoa farming communities and households. The approach should go beyond simply telling farmers about child labour laws that must be obeyed, to provide appropriate technical and other competencies. This should include basic knowledge in first aid and treatment procedures, and home management knowledge that can influence household labour practices in the interest of the child and sustainable cocoa production. Such extension strategy should also be able to identify and report situations of serious violation of children rights, including child labour and trafficking to the appropriate agencies for redress. Finally, the strategy will require retooling of frontline cocoa extension staff in Ghana with the requisite competencies to respond effectively to the broader
training needs of cocoa production households.

References


Acknowledgements

The author wishes to acknowledge Dr. Moses Ogoe whose supervised-scholarly work provided considerable input into the paper. Appreciation also goes to Dr. Albert Obeng Mensah whose critical comments on the subject provided great insight in shaping the paper. All farmers and staff of the Cocoa Health and Extension Division of Ghana Cocoa Board are also appreciated for sharing their experiences on the subject.
Attitudes and Adoption of Rainwater Harvesting: Influence of Gender, Awareness, and Social Status

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Texas Tech University

Jonathan Ulmer
Kansas State University

Mary Murimi
Rudy Ritz
Texas Tech University

Abstract
Inadequate potable water often leads to hygiene-related infections while general lack of water for agriculture is a precursor to malnutrition in Sub-Saharan Africa. There is a widespread low adoption of rooftop rainwater harvesting in Kenya. Attitudes influence the level of farmers’ participation in water harvesting. Literature on the influence of gender, level of education, and socioeconomic status (SES) on attitudes toward rainwater harvesting among smallholder farmers is inadequate. This study was conducted to fill that knowledge gap. The study was conducted in four sub-counties in Kenya. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20. Level of significance was set at $\alpha = .05$. Effect size was calculated and presented as Cohen’s $d$ for the independent t-tests and as omega squared ($\omega^2$) for the one-way ANOVA. Post hoc tests were conducted using Gabriel’s procedure. Results indicated that women had statistically significant better attitudes toward rainwater harvesting than men. Level of formal education among smallholder farmers did not indicate a statistically significant difference in attitudes. Comparisons across SES levels indicated a statistically significant difference in attitudes toward rainwater harvesting. Attitudes were determined to be a statistically significant predictor of adoption of rainwater harvesting. The researchers envision that these findings will be helpful to program planners, policy makers, agricultural educators, and curriculum designers in Kenya. The study expounded on knowledge on demographic-related attitudinal barriers to prioritization and adoption of rainwater harvesting. Recommendations to policy makers and educators on enhanced extension and outreach programs were proposed. Involvement of women as change agents was recommended. Further research on suitable and relevant extension methods was recommended.

Keywords: Adoption, attitudes, education, rainwater harvesting, socioeconomic status
Introduction

Studies have indicated that there is low adoption of rooftop rainwater harvesting in Kenya (Berger, 2011). The increase in human population has resulted in an unprecedented surge in the need for clean and safe water. Water has many purposes such as industrial, agricultural, home, and recreational uses. Natural ground water reservoirs are over-used, leading to lowering of water tables. Deforestation has seriously reduced recharge rate to the water table in many regions of the world (Mahe et al., 2013). Many rural households rely on natural ground water sources such as shallow wells, boreholes, dams, rivers, and lakes. Water conservation and utilization is fundamental in fostering local, regional, and international peace and development (Baguma, Hashim, Aljunid, & Loiskandl, 2013). According to Silali and Njambi (2014), about 37% of the total population in developing countries lack adequate access to clean and safe water. The problem is severe in Sub-Saharan African countries.

The struggle for access to available water in Sub-Saharan Africa is regarded among many as the most likely cause of intercommunity conflict in the region (Matiza, 2000). Domestic conflicts over access and use of water are constantly reported in many parts of the world (Baez, 2011). In April 1, 2014, Gerald Bwisa, an author with one of the largest and most respected newspapers in East Africa, Daily Nation, wrote a story about a domestic conflict resulting from scarcity of water. He narrated how an employer bit her house-help worker alleging misuse of water. The author quotes the house-help as saying; “I was washing utensils as usual when my employer came and questioned why I was misusing water. She slapped me twice and went ahead to biting me on my shoulder. Previously she had threatened to discipline me” (Bwisa, 2014, April 2, p. 1). Similar stories are told in many households across Kenya.

Theoretical Framework

This research was based on the Diffusion of Innovations Theory (Rogers, 2003). Rogers defines diffusion as the process by which an idea or innovation spreads through certain communication channels from the source to members of a social system over time. Adoption is the process that involves a series of stages that an individual undergoes from the time of first encounter with an idea to the point that it becomes a part of his/her life.

The stages of adoption are: 1) awareness; when an individual comes into contact with an innovation, 2) interest; when an individual develops liking for an innovation, 3) evaluation; in this stage, an individual seeks for rationale and judges the merits of an innovation, 4) trial; an individual puts the innovation into use in a small scale, and 5) adoption; the individual takes up the innovation and it becomes part of his life (Rogers, 2003).

Rogers (2003) describes five important, systematic, and logical steps of the innovation-decision process. These are: 1) knowledge, 2) persuasion or conviction that results in attitude formation, 3) decision or making a choice to either accept and try out or reject the innovation, 4) implementation or execution which involves putting the idea into practice, and, finally, 5) confirmation which involves seeking more ideas and resources to support the progress of the decision made.

Ganpat, Harder, and Moore (2014) indicated that agricultural extension systems usually use collaborative strategies in the decision making process aimed for a larger program. The decision-making process among smallholder farmers is related to characteristics of an innovation: 1) relative advantage of the innovation, 2) trialability or
the propensity to put the innovation into practical use, 3) compatibility with present farming activities, 4) complexity or easiness to adopt, and 5) observability or the possibility of observable positive outcomes because of adopting the innovation (Rogers, 2003).

According to Rogers (2003), five distinct categories of adopters exist. Each category has certain unique characteristics but the boundary between categories is often blurred. Since this categorization is rate based, time is a common factor. He assigned specific percentages to each category: (1) innovators; 2.5%, (2) early adopters; 13.5%, (3) early majority; 34%, (4) late majority; 34%, and (5) laggards; 16%.

In their research on goal-directed behavior, Ajzen and Madden (1986) argued that beliefs and attitudes toward an innovation are associated with the expected behavior or practice. Ajzen (1991) explains that normative beliefs, attitudes, and subjective norms are common factors that lead to certain observable actions/behavior among people. In his ground-breaking study, Theory of Planned Behavior (TPB), Ajzen asserts that intentions are guided by attitudes and that they represent the conscious motivation to a behavior. Previous studies indicate that low adoption of rainwater harvesting in developing countries is mainly due to low prioritization, and thus, farmers allocate little income from their savings to the activity (Lourete, Tsukada, & Lehmann, 2009). The construction of the research instruments was guided by Ajzen and Rogers works.

**Purpose and Objectives**

The purpose of this study was twofold: one, to develop an understanding of how gender, level of education, and socioeconomic status (SES) related to the attitudes toward prioritization and adoption of rainwater harvesting among smallholder farmers, and two, to investigate whether attitudes, socioeconomic status, and awareness are related to adoption of rainwater harvesting. The following objectives guided the study:

1. Determine whether small holder farmers’ attitudes toward rainwater harvesting vary with their gender.
2. Determine whether small holder farmers’ attitudes toward rainwater harvesting vary with their levels of education.
3. Determine whether small holder farmers’ attitudes toward rainwater harvesting vary with their socioeconomic status.
4. Determine whether adoption is related to attitudes, awareness, and socioeconomic status.

**Methods**

Participants in this study were smallholder farmers drawn from four sub-counties: Meru South and Maara in Tharaka-Nithi county and Bahati and Subukia in Nakuru county. A majority of rural dwellers in both counties are predominantly farmers. An ex-post facto design was used in this study. In an ex-post facto design, independent variables are studied after their effects have occurred (Ary, Jacobs, & Razavieh, 2009). The researchers investigated independent variables in retrospect for possible connectedness and influence on the dependent variables (Cohen, Manion, & Morrison, 2000). Simple random sampling was used in selecting participants for inclusion in the study. The recommendation for getting a sample size by Mugenda and Mugenda (1999) was used. The sampling frame comprised 1638 households. The sample size for this study was 310 participants where one adult participant represented a household. This initial selection was done
on household basis. To have parity in gender representation, a simple random selection of households was adopted where male and female participants were alternated in the list of households. In social science research where quantitative type of data are collected, a sample size of more than 30 participants can be considered adequate to provide basis for inference (Hinkle, Wiersma, & Jurs, 2003). Borg and Gall (1979) suggested that in survey research, a sample size of not less than 100 participants in each major grouping and between 20 and 50 participants in a minor subgroup should be ensured. The primary variables of interest, namely, level of education and SES, were considered the major groupings and mutually exclusive. A researcher-designed questionnaire was used. Validity informs that the instrument is measuring what it ought to measure (Field, 2013). Validity of each scale on the instrument was established by a panel of four experts comprised of faculty members. Cronbach reliability coefficient was established for the two sets of questions that represented attitudes and awareness. An alpha level of .70 and .72 was established for attitudes and awareness, respectively. Awareness was determined by knowledge-based questions.

The level of adoption of rainwater harvesting was determined by scores obtained from questions that sought data on the quantity of water reservoir in relation to perceived income. The participants’ scores on this variable constituted their level of adoption of rainwater harvesting. A summated composite score was computed using SPSS. Attitudes toward rainwater harvesting were determined using 14 items; 13 of the items were measured on a five-point scale with responses as strongly agree, agree, undecided, disagree, and strongly disagree; and one item was measured on a three-point scale. This one question stated that, “How interested are you in obtaining more information about rain water harvesting? (Check one answer) (a) Very Interested (b) Slightly Interested (c) Not Interested.” The maximum attainable score was 68 points. A higher score indicated a higher positive attitude.

Socioeconomic status was measured on a nominal scale using the researcher developed questionnaire. Indicators for socio-economic status included, types of house, owning and operating bank account, owning a car, ability to own a car, owning cattle, sheep, and/or goats. A composite score was computed from the six questions. The computed composite score was recomputed to ordinal level yielding a new variable with five levels of socioeconomic category. The five socioeconomic status groups were labelled as very low, low, middle, above average, and high (Antonovsky, 1967). Social economic status is a rather complex phenomenon and has no single agreed upon way of measuring. It depends on several factors and context of the research (Meyer et al., 2014).

Descriptive statistics used in data analysis included frequencies, means, and standard deviations. Inferential statistics that were used to explain the data included Pearson’s product moment correlation (r), independent samples t-test, linear multiple regression, and one-way analysis of variance (ANOVA). Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20. Significance level was set at α = .05 (Hinkle, et al., 2003).

**Results**

Objective one was to determine whether small holder farmers’ attitudes toward rainwater harvesting varied with gender. A gender comparison of attitudes toward rainwater harvesting indicated that women participants scored an average of 73.2% ($M = 49.79$, $SD = 6.55$, $n = 175$) while their male counterparts had an average
of 70.4% (\(M = 47.87, SD = 5.61, n = 135\)). Although the male and female numbers were expected to be the same, it was difficult finding male household heads in some households as they were out for work. In such a case, a female acting as the household head was interviewed.

A comparison by gender was conducted using an independent samples \(t\)-test. Table 1 presents results of the independent samples \(t\)-test between attitudes’ scores of male and female smallholder farmers (\(N = 310\)). Results indicated a statistically significant difference, \(t(308) = -2.72, p = .007, d = 0.34\). The effect size, Cohen’s \(d = 0.34\), was small according to Cohen (1988).

### Table 1

<table>
<thead>
<tr>
<th>Gender</th>
<th>(n)</th>
<th>(M)</th>
<th>(SD)</th>
<th>(df)</th>
<th>(t)</th>
<th>(p)</th>
<th>(d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>135</td>
<td>47.87</td>
<td>5.61</td>
<td>308</td>
<td>-2.72</td>
<td>.007</td>
<td>0.34</td>
</tr>
<tr>
<td>Females</td>
<td>175</td>
<td>49.79</td>
<td>6.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. \(N = 310\), \(p < .05\)

Objective two was to describe the influence of the level of formal education on participants’ attitudes toward rainwater harvesting. Participants were classified into five categories as follows; 1) not literate, 2) elementary/primary level, 3) secondary/high school level, 4) middle level/community college, and 5) university level. The primary/elementary school category indicated the highest attitudinal score (\(M = 49.79, SD = 6.32, n = 131\)) while those not literate had the lowest attitudinal score (\(M = 47.15, SD = 5.84, n = 39\)). Table 2 shows descriptive results of attitudes’ score based on smallholder farmers’ level of formal education.

### Table 2

<table>
<thead>
<tr>
<th>Education level</th>
<th>(M)</th>
<th>(SD)</th>
<th>(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not literate</td>
<td>47.15</td>
<td>5.84</td>
<td>39</td>
</tr>
<tr>
<td>Primary/elementary</td>
<td>49.79</td>
<td>6.32</td>
<td>131</td>
</tr>
<tr>
<td>Secondary/High school</td>
<td>48.46</td>
<td>6.32</td>
<td>100</td>
</tr>
<tr>
<td>College</td>
<td>49.61</td>
<td>6.08</td>
<td>28</td>
</tr>
<tr>
<td>University</td>
<td>48.25</td>
<td>4.94</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>48.95</td>
<td>6.22</td>
<td>310</td>
</tr>
</tbody>
</table>

Note. \(N = 310\)

A one-way ANOVA test indicated that there was no significant difference in the group means, \(F(4, 305) = 1.69, p = .15, \omega = .09\). Effect size measured as omega squared indicated negligible practical significance, \((\omega^2 = 0.008\). Table 3 shows a summary of the results.
Objective three was to determine whether small holder farmers’ attitudes toward rainwater harvesting vary with their socio-economic status. Five socioeconomic status groups—very low, low, middle, above average, and high were compared on the mean score of their attitudes towards rainwater harvesting. The low group had the most positive attitudes with the highest attitudes score ($M = 50.04$, $SD = 5.86$, $n = 112$), while high socioeconomic status group had the lowest positive attitudes as expressed in the scores ($M = 45.14$, $SD = 5.52$, $n = 14$). Table 4 shows descriptive analysis of participants’ attitudes towards rainwater harvesting based on the socioeconomic categories.

Table 4

<table>
<thead>
<tr>
<th>Socioeconomic category</th>
<th>$M$</th>
<th>$SD$</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>48.11</td>
<td>7.26</td>
<td>47</td>
</tr>
<tr>
<td>Low</td>
<td>50.04</td>
<td>5.86</td>
<td>112</td>
</tr>
<tr>
<td>Middle</td>
<td>48.62</td>
<td>5.84</td>
<td>100</td>
</tr>
<tr>
<td>Above average</td>
<td>49.05</td>
<td>6.61</td>
<td>37</td>
</tr>
<tr>
<td>High</td>
<td>45.14</td>
<td>5.52</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>48.95</td>
<td>6.22</td>
<td>310</td>
</tr>
</tbody>
</table>

Note. $N = 310$

The attitudes mean scores for the five socioeconomic categories were compared using one-way ANOVA. Results showed that there was a statistically significant difference between the means of at least two groups, $F(4, 305) = 2.51$, $p = .04$, $\omega = .14$. Table 5 provides results of the one-way ANOVA.

Table 5

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>$df$</th>
<th>$MS$</th>
<th>$F$</th>
<th>$p$</th>
<th>$\omega$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>381.86</td>
<td>4</td>
<td>95.47</td>
<td>2.51</td>
<td>.04</td>
<td>.14</td>
</tr>
<tr>
<td>Within</td>
<td>11582.41</td>
<td>305</td>
<td>37.98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11964.27</td>
<td>309</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $N = 310$, $p < .05$
Since the overall $F$-test yielded significant results, ($p = .04$), follow up post hoc tests were conducted for multiple comparison of the attitudes means for the five socioeconomic categories. Gabriel’s post hoc procedure was used due to varying small group sizes. There were two groups that were statistically significantly different, low ($M = 50.04$, $SD = 5.86$, $n = 112$), and high ($M = 45.14$, $SD = 5.52$, $n = 14$), $p = .02$.

Objective four was to determine whether adoption is related to attitudes, awareness, and socioeconomic status. The tank size was used as a determinant of participant’s level of adoption in relation to their income and family size. Equitable tank size for an average family of five members was scored highest in a five-point scale. Pearson’s product moment correlation ($r$) procedure was conducted to determine the nature of relationship between adoption, awareness, attitudes, and SES index (Field, 2013). Davis (1971) adjectives were used to describe the magnitude of Pearson’s product moment correlations ($r$).

Results indicated negligible positive correlation ($r = .03$) between adoption ($M = 5.41$, $SD = 2.08$) and SES index ($M = 13.17$, $SD = 2.91$). A negligible negative correlation ($r = -.08$) was indicated between adoption ($M = 5.41$, $SD = 2.08$) and awareness ($M = 21.81$, $SD = 2.95$). Analysis indicated low positive correlation ($r = .23$) between adoption ($M = 5.41$, $SD = 2.08$) and attitudes ($M = 48.95$, $SD = 6.22$). This correlation was statistically significant. Table 6 provides summarized results of the analysis.

### Table 6

**Pearson’s Product-Moment Correlations Between Adoption, Awareness, SES Index and Attitudes**

<table>
<thead>
<tr>
<th>Variables</th>
<th>$Y$</th>
<th>$X_1$</th>
<th>$X_2$</th>
<th>$X_3$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption ($Y$)</td>
<td>–</td>
<td>-.08</td>
<td>.23</td>
<td>.03</td>
<td>5.41</td>
<td>2.08</td>
</tr>
<tr>
<td>Awareness ($X_1$)</td>
<td>–</td>
<td>-.02</td>
<td>.13</td>
<td>-.05</td>
<td>21.81</td>
<td>2.95</td>
</tr>
<tr>
<td>Attitude ($X_2$)</td>
<td>–</td>
<td></td>
<td></td>
<td>-</td>
<td>48.95</td>
<td>6.22</td>
</tr>
<tr>
<td>SES index ($X_3$)</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td>13.17</td>
<td>2.91</td>
</tr>
</tbody>
</table>

**Note:** $N = 310$

### Conclusions and Implications

Objective one was to determine whether small holder farmers’ attitudes toward rainwater harvesting vary with gender. To get a deeper understanding of how attitudes influence decision making, the researchers investigated how attitudes towards rainwater harvesting varied across various levels of selected demographics. Variation in attitudes across these levels was used as implicative predictor of how demographics influence prioritization of rainwater harvesting (Little, 2013).

Data analysis on attitudes toward rainwater harvesting indicated statistically significant difference between male and female participants. The effect size, Cohen’s $d$, was small, $t(308) = -2.72$, $p = .007$, $d = 0.34$. These results led to the conclusion that women have more positive attitudes toward rainwater harvesting than men. These findings support results by Berger (2011) that indicated women have more positive attitudes toward water conservation at the family level. This implies that there is a need for enhanced extension programs that focus on rainwater harvesting among women.

Objective two was to determine whether small holder farmers’ attitudes...
toward rainwater harvesting vary with their levels of education. From the results, it was indicated that there was no statistically significant mean difference in attitudes toward rainwater harvesting across the five groups of participants based on their level of formal education. It was concluded that small farmers’ attitudes toward rainwater harvesting did not vary with their levels of education.

Objective three was to determine whether smallholder farmers’ attitudes toward rainwater harvesting vary with their socio-economic status. It can be concluded that smallholder farmers in the low socioeconomic status have better positive attitudes toward rainwater harvesting than those in higher socioeconomic status. These findings concur with results reported by Mwaniki (1986) who found that resource-limited smallholder farmers in Mbeere, Kenya, particularly women, have a lot of intrinsic motivation toward making their family lives better.

Objective four was to determine whether adoption is related to attitudes, awareness, and socioeconomic status. It was concluded that attitudes represented the only variable positively correlated with the adoption of rainwater harvesting. Conversely, SES is not likely to impact adoption. The theory of Planned Behavior provides important descriptions and explanation of the close relationship between expressed behavior of people and a combination of norms, beliefs, attitudes, and intentions (Ajzen, 1991).

A related study conducted in a developing country in Asia (Rezvanfar, Ghorbanian, & Shafiee, 2014) revealed that attitudes have greater influence on the decisions that are made by individuals regardless of the codified knowledge that is available to them. The findings by Rezvanfar et al. agree with the premise of the theory of planned behavior (TPB) that attitudes and beliefs have great influence on an individual’s behavior (Munro, Lewin, Swart, & Volmink, 2007). It can be concluded that if the attitude toward rainwater harvesting is positive, then, there is a great tendency of adopting rainwater harvesting practice.

Recommendations for Practice

This research study investigated smallholder farmers’ attitudes in relation to prioritizing and adopting rainwater harvesting. Based on prospect theory (Griesdorn, 2011), it can be argued that farmers are aversive to investing money for long term rainwater harvesting as they are not certain if the investment will pay off. It is therefore recommended that curriculum planners in agricultural education consider integrating attitudinal and economic aspects of rainwater harvesting in the curriculum.

Lourette et al. (2009) noted that although some studies indicate that inadequate resources among smallholder farmers negatively impact their decision-making process, many of the challenges in rainwater harvesting have been attributed to inadequate knowledge about economics of rainwater harvesting. It was therefore recommended that government extension agents and other institutions offering extension services make a deliberate effort to educate farmers on the economics of rainwater harvesting in relation to time saved in man-hours for other income generating activities.

Women indicated more positive attitudes toward rainwater harvesting than men. Based on these findings, we recommend that women involvement in outreach programs be enhanced. Also, curriculum developers and extension program planners should draw from the findings of this study to promote rainwater harvesting among women. This recommendation is augmented by the fact
that if the attitude toward rainwater harvesting is positive, then, there is a great tendency of adopting rainwater harvesting practice.

**Recommendations for Research**

Research should be conducted on extension methods that could enhance positive attitudes toward adoption of rainwater harvesting. Follow-up research should be conducted to ascertain actual cost of setting up a sustainable rainwater harvesting system that can satisfy water needs of an average family size of five members. The researchers recommend replicating this research in other regions of the country (Kenya) and comparing it to the findings of this research. Thus, generalization of the results in regions with similar geographic and socioeconomic characteristics will be more realistic and empirically tenable.

This study was primarily preliminary research and it specifically employed a classical quantitative approach (Ary et al., 2009). Integrating qualitative methods in quantitative research allows for thick and richer data (Guba, 1990). It is recommended that mixed method research be conducted to provide more insight on why prioritization of rainwater harvesting has generally remained low among smallholder farmers.

**References**


*The Milbank Memorial Fund Quarterly, 45*(2), 31-73.


Behavioral Sciences, 152, 65-69.
doi: 10.1016/j.sbspro.2014.09.155


Adoptive Behaviors of Farmers After Training and Their Subsequent Diffusive Behaviors
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Abstract
This study focused on Kenyan farmers in the Moiben area who participated in three agricultural seminars at Twiga demonstration farm. The problem of interest was the need for increased dissemination of improved agricultural practices to enhance production and processing of crops related to food security and socio-economic well-being. The study investigated associations between adoptive behaviors of participants and their subsequent behavior related to diffusing improved practices to others. Data was collected using a demographic questionnaire and two structured interview schedules. Correlational analysis was conducted on post-training behavior variables, using Kendall’s tau calculations. The study found that farmers across the samples who exhibited higher levels of adoption of workshop-recommended innovations also had a moderate to strong likelihood of showing correspondingly higher levels of diffusion-related behavior. It was concluded that these findings align well with Rogers’ (2003) discussion of change-agent credibility, and also with Bandura’s (2006) work on social modeling and perceived self-efficacy. It was recommended that offering community-based agricultural seminars such as those in this study be continued and expanded, as an important component in a pluralistic model of agricultural extension methodology for Sub-Saharan Africa. It was further recommended that farmers who adopt improved practices learned in training be identified specifically for further interventions related to implementation and diffusion of agricultural innovations.

Keywords: Technology, innovations, adoption, diffusion, Extension, participation, social-learning framework, social network, farmer-to-farmer
**Introduction**

At a time when considerable progress in the area of food security has occurred in many parts of the world, sub-Saharan Africa continues to suffer chronic and recurrent undernourishment, with a quarter of its population so affected (Baro & Deubel, 2006; United Nations Development Program [UNDP], 2012). This is the only region that has not experienced any reduction in the number of undernourished people since 1990 (United Nations Economic and Social Council, Economic Commission for Africa, 2011). Projections suggest that this trend will probably continue more or less the same in 2020 (Rukuni, 2002). The disparity between food-security indicators in Africa and in most other parts of the world makes it unlikely that inadequate agricultural knowledge or technology is primarily to blame. One possible contributing factor, however, to large-scale hunger in sub-Saharan Africa is inefficiency in the diffusion of important agricultural innovations at the level of small-holder farmers. According to Kroma (2003), "There is a wide gap between agricultural technologies produced in research institutions and the adoption of such technologies by small farmers and rural households in sub-Saharan Africa."

**Literature Review**

A number of efforts have been made to assess the overall effectiveness of agricultural extension work in Sub-Saharan Africa. Davis (2008), reviewing what has been done, concluded that “little is known about the capacity, quality of service, and performance of extension systems in Sub-Saharan Africa. Agricultural extension services in the region have been chronically under-funded, and few governments can allocate more resources (Venkatesan, 1996). Eicher (2003) noted that during the 1990s donor funding to African agriculture declined, but at the same time the number of programs rose. This suggests that although agricultural extension systems in sub-Saharan Africa can probably make significant contributions to improvement in regional food security, it will be necessary to identify supplementary mechanisms in the effort to redress the pattern of recurrent famine.

Juma (2011) proposed the concept of *innovation systems* as a framework through which to understand national and regional economies. He defined an innovation system as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance. There is value, however, in seeing the wider context in which the diffusion of agricultural innovations, in particular, is an important component. Juma focused his study primarily on agricultural innovation on the African continent. Miller and Shinn (2012), referring to Juma’s research, observed that “Innovation systems are integral to African agricultural development.” Rivera (2006) stressed the importance of a comprehensive vision for investing in innovation research and encouraging innovation development, from the national to the local level.

Davis and Place (2003), building on the work of Anderson and Crowder (2000), observed that there is a movement toward a pluralistic model of extension services in Africa. Governments have not been able consistently or adequately to fund delivery of extension services, and NGOs have had neither the coordination nor the long-term funding to fill the need. Birner et al. (2006) provided a detailed discussion of how this kind of pluralistic, multi-faceted approach to extension services might be designed.
Mwangi (1998) noted that extension workers can increase their own effectiveness in facilitating adoption of improvements by investing time in developing relationships of trust and rapport with farmers. A study of Integrated Pest Management (IPM) dissemination in Uganda (Erbaugh, Kibwika, & Donnermeyer, 2007) assessed knowledge levels of extension agents and found low levels for almost half of them. The authors recommended strategies for knowledge improvement as a way of increasing rates of IPM diffusion. Follow-up research concluded that “farmers’ participation in on-farm trial demonstrations, accessing agricultural knowledge through researchers, and prior participation in pest training were associated with increased adoption of most IPM practices” (Bonabana-Wabbi, 2002).

Erbaugh, Maseki, Kilima, and Larson (2011) studied constraints on adoption of improved sorghum varieties in Tanzania. They identified limitations such as the effects of inconsistent rain on seed multipliers, low demand for retailers, poor transportation infrastructure for distributors, and uneven knowledge on the part of extension agents.

There has been a growing consensus that enlisting as much local participation as possible in training, learning, and decision-making has a strong positive influence toward adoption and implementation of agricultural innovations. Kroma (2003) explored a farmer-centered, participatory approach to management of innovations in Ghana, using a social-learning framework. An overview and evaluation of participatory methods in extension delivery appeared in Davis’ (2008) survey of extension models in Africa. This sort of partnership has seemed to be especially needful when dealing with a technological innovation or adaptation of technology (Lev and Acker, 1994).

Vreyens (1999) stressed the importance of becoming familiar with local farmers’ internal thought processes regarding decisions about adopting new methods or technology, in order for a change agent to select the most effective approach in encouraging adoption. This was the approach of Tuttle, Lindner and Dooley (2004) in their study of farmer preferences in regard to extension delivery methods in Mexico. They found that with reference to the format of community seminars, both male and female farmers “favored hands-on delivery strategies that included a social component.”

Ketema’s (2008) research in Ethiopia showed that networks of family and friends were the most effective sources of information relating to diffusion of innovations. He recommended forming informal farmers’ networks to capitalize on social networking for encouraging adoption of improvements. A significant rate of innovation diffusion in a community seems to require a certain "critical mass" or proportion of farmers who have received appropriate sensitization and training (Rogers, 2003).

An analysis of extension methodologies in Tanzania emphasized the need to include greater participation by local farmers in planning and execution (Douglah & Sicilima, 1997). Vatta et al. (2008) conducted research on goat health with participation from Zulu farmers. Involving these farmers in the research process itself was associated with a subsequent increase in their effectiveness in farmer-to-farmer diffusion of knowledge. Research by Pedzisa, Minde, and Twomlow (2010) in Zimbabwe found that technology demonstration with farmer participation was a major positive factor in subsequent adoption and adaptation of the innovation.

Davis (2004) made an extensive study of the technology dissemination among farmers in Meru Central District, Kenya, and how this process was affected by
farmers’ participation in local groups. She determined that some factors related to participants’ success in technology diffusion were the kind of group, the age of the group, location of the group, amount of training done with the group, homogeneity of the group, and the number of group linkages to other entities and networks. Davis and Negash (2007) followed with an analysis of wealth and gender as factors in the performance of farmers’ groups in the same district. Wealth was not found to be highly influential, but there was gender-related differentiation of activity.

Wambugu studied farmers’ adoption of fodder shrubs in Kenya and concluded that participation in farmers’ groups was an important positive factor in that process (Franzel, Wambugu, & Tuwei, 2003; Wambugu, 2006). Juma (2011), in his lengthy treatment of agricultural-innovation systems, advocated taking advantage of existing traditional and cultural community structures as linkages necessary for storing and disseminating knowledge.

Theoretical Framework
The theoretical framework for the study was the work of Everett Rogers (2003) on the diffusion of innovations, with a focus on how well Kenyan farmer-participants in agricultural workshops performed as informal change agents to diffuse innovations in the local community. Rogers argued that innovation diffusion can be advanced by informal change agents, persons who influence others in their social networks to consider and eventually adopt a new practice or technology. The study focused on seminar attendees first as innovation adopters themselves, who might then become informal change agents diffusing the innovation to others. Next, the same farmers were interviewed to assess the degree to which they as adopters had influenced other members of their social networks. Correlations between the selected variables and the data gathered from follow-up interviews with farmers were interpreted in light of Rogers’ theoretical framework, with particular attention to his discussion of diffusion networks and the role of the informal change agent.

Purpose and Objective
The purpose of the study was to identify and describe associations between the adoptive behaviors of participants and their subsequent diffusive behaviors as farmers in the Uasin Gishu County of Kenya in the dissemination of agricultural innovations. Innovations that can potentially improve agricultural yields and add value are available, but sub-Saharan smallholder farmers have been slow to adopt these innovations (Aker, 2010; Diagne, n.d.; UNDP; Nkonya, Koo, Marenya, & Licker, 2012). It was hoped that by adding to the knowledge of how key variables function in association with innovation diffusion by informal change agents, the study would contribute to the capacity of these Kenyan farmers to promote improved agricultural practice and consequently better food security and quality of life in the region.

Delimitations, Limitations and Assumptions
This study proceeded with the following geographical, demographic, temporal and numeric delimitations. Research participants all lived and conducted farming activities within the area of a ten-kilometer radius of the demonstration farm at which the three agricultural workshops took place.

Several factors affecting the study could not be controlled and must be noted as limitations to be taken into account when evaluating the results and interpreting the findings. One was that the research samples were necessarily convenient rather than
random in nature, consisting of farmers who chose to attend agricultural seminars. This weakened the possibility of extrapolating results to the general population of Kenyan or sub-Saharan African farmers.

Two additional limitations were related to language requirements and distance from the site, both of which made it necessary to rely on Kenyan research assistants. The first language of almost all of the research respondents is Kalenjin. Local informants unanimously recommended that the survey and structured-interview instruments be printed in English, for the sake of precision and also because the local population is accustomed to English as a medium for communication related to education. At the same time, the recommendation was made that these instruments be administered by persons competent in both English and Kalenjin, so that explanation could be provided as needed in more than one linguistic channel.

Finally, the amount of time allowed between each of the three workshops and the first follow-up interview (relating to adoption of innovations by training participants), and between the first- and second-round interviews (relating to diffusion of innovations by training participants) was a limitation. Both of these time intervals were about four or five weeks in most cases. It is possible or even likely that longer intervening time periods would have resulted in findings of higher degrees of both participants’ adoption and diffusion than were recorded in the study.

The first of several assumptions guiding the study was that the innovations recommended in the agricultural workshops for adoption by farmers would actually be beneficial to them. Second, it was assumed that a period of about four weeks would make it possible, at least for farmers in the innovator and early-adopter, if not early-majority, categories, to make an initial decision about adoption and take some preliminary or threshold action on adoption. A third assumption was similar, that another four weeks (or at least eight weeks after a workshop) would allow a reasonable opportunity for others in the workshop participants’ networks to begin to be influenced by the trainees’ activities as informal change agents in the diffusion process.

Methodology

The context of this study was the farming community of Twiga, which is roughly 25 miles north-northeast of the city of Eldoret and 30 miles southeast of the town of Kitale. Most of the residents are ethnically Kalenjin with few ethnic Luhyas. Most residents in and around Moiben are smallholder farmers who cultivate maize (corn) and wheat primarily, along with lesser amounts of a number of other cereal, root-and-tuber, and leaf crops. The Twiga demonstration farm consists of about three acres of land on which a variety of selected plants and trees are cultivated in ways designed to exemplify best agricultural and horticultural practices.

Three agricultural seminars presented at the farm provided the basis for this study. The first concerned management and care of dairy cattle (November 2011). The second was on poultry projects (December 2011). The third was a workshop on bee-keeping (January 2012). Improved practices recommended for dairy cattle included a feeding regimen of Napier grass, maize stover, wheat stems, and bean straw; clean drinking water supply; AI for breeding; and health-maintenance measures such as de-worming, spraying, and dipping. Recommendations for poultry farmers were using a house with raised or cement floor; acquiring improved breeds; implementing regular vaccination or adding more types; increasing feed variety; and using a chick
brooder. For bee-keeping, trainers recommended starting apiaries; acquiring improved hives; maintaining hive health by access to clean water, access to food, protection from predators, and safe distance from humans; and harvesting and processing improvements such as harvesting in late evening and early morning, using clean storage containers, and utilizing effective purification methods.

Population and samples
The target population for the study was Kenyan farmers. According to the CIA’s World Factbook (2014), the total rural population in Kenya is estimated at 33,559,306. The accessible population for the research was farmers living within an eight-kilometer radius of the Moiben community/trading center in the Uasin Gishu County, Kenya. The total population in this area is estimated to be approximately 12,696 people (Falling Rain, 2010). Applying the national percentage of the total population aged fifteen-to-sixty-four (55.1%) yields a rough estimate of the number of active farmers in the accessible population of 6,995. The sample sizes were 32 persons (dairy-management seminar), 30 persons (poultry-keeping seminar), and 28 persons (bee-keeping seminar).

Instrumentation
A preliminary survey was administered to farmers who participated in the three agricultural workshops at Twiga. The purpose of this instrument was to estimate parameters of the target population to help determine the external validity of the study. Most of the demographic data was nominal and ordinal in nature, the exceptions being the ages and farm sizes of the respondents. The data gathered by means of this survey were foundational in selecting and operationalizing the variables used in the correlational analysis.

Data Collection
The questionnaires were administered by research assistants. The administration of the data-collection instruments typically took place at the workshop venue on the demonstration farm or respondent’s home. In most cases a research assistant carefully explained each item. After responses on each questionnaire were recorded, the items were reviewed to check for completeness and intelligibility of the data provided. When any question arose in relation to the recorded information from participants, one of the research assistants contacted the respondent again to clarify or amplify his or her response. This review and follow-up procedure provided further warrant for confidence in the reliability of the data received. The likelihood of the occurrence of non-response issues was negligible because of the direct administration of the interview schedules by the research assistants to the seminar participants.

Data Analysis
Most of the data collected during the follow-up interviews was categorical rather than interval-level. Accordingly, two nonparametric correlations were considered to analyze the data: Spearman’s rho ($r_s$) and Kendall’s tau ($\tau$). Field (2009), in his chapter on correlations, noted that while Spearman’s rho is the more popular of the two, Kendall’s tau is probably more appropriate for relatively small sample sizes and data that contain many similar values. He added that the latter may also provide a more accurate indication of the actual correlation in the population. Based on these observations, it was decided to rely on Kendall’s tau for this study’s analyses of correlations between measurements of adoptive and diffusive behaviors.
The use of descriptive data in combination with correlational analysis has been used in a number of other studies. An Indian researcher conducted an inquiry into consumer adoption of personal computers in India, investigating relationships between demographic variables and adoption and behaviors in ways similar to those used in the present study (Krishnaswamy, 2006). Decker’s (1987) research in business sociology reflected similar methodology and Bursal (2006) investigated mathematics-related anxiety in pre-service elementary teachers with correlational analysis. The work of Cavane and Donovan (2011) on the adoption of improved maize varieties and chemical fertilizers was correlational research. Adisa (2011) utilized descriptive-questionnaire data and basic correlational analysis to research conflicts between farmers and herdsmen in Nigeria.

Findings
Among the improved practices recommended in the dairy-management workshop (diversification of feed components, regular treatment and prevention of parasite infestation, and artificial insemination), participant-adopters reported highest levels of dissemination to one or more persons of improved feed ingredients (84%), and least dissemination of A.I. (28%). Recommendations from the poultry seminar included improved housing, improved breeds, use or increased use of vaccination, greater variety of feeds, and use of a chick brooder. Follow-up interviews with trainees indicated most effective diffusion to other farmers of using greater poultry feed variety (53%), and lowest level of dissemination for use of a chick brooder (13%). The bee-keeping workshop covered several improved practices, including use of improved hives, proper maintenance of hives, and optimal methods of harvesting and processing (in addition to starting an apiary, for those not having kept bees before). The highest rate of dissemination to one or more other farmers was 68% for initiating an apiary, followed closely by use of improved harvesting and processing techniques (67%). Effective hive-maintenance practices were disseminated at the lowest rate for this seminar (50%).

The dataset from each of the agricultural seminars was analyzed separately. Tables 1-3 contain the results of the correlational analyses conducted on five variables, two connected with adoption behaviors and three connected with diffusion behaviors. Two of the variables were binary (adopter/non-adopter, diffuser/non-diffuser). The others were ordinal measures of the extent of adoption or diffusion behaviors, either in terms of the number of recommended practices implemented/disseminated or in terms of the participants’ reports of the number of other people who adopted particular innovations.

Table 1 presents Kendall’s $\tau$ ($\tau$) correlations among these five variables calculated for the participants in the dairy-management seminar. Most of the correlations were small and positive, except for the association between the extent of adoption and the extent of diffusion by number of innovations. These two were correlated with a medium-sized positive $\tau$ coefficient (.41).
Table 1

**Correlations Between Adoption and Diffusion Behaviors (Dairy-Management)**

<table>
<thead>
<tr>
<th>Adopter or non-adopter</th>
<th>Extent of diffusion by # innovations diffused</th>
<th>Extent of diffusion, by est. # who later adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficients</td>
<td>Diffuser or non-diffuser</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td>τ</td>
<td>.22</td>
</tr>
</tbody>
</table>

*Note.* n = 32.

Table 2 displays results of correlational calculations among five variables related to adoption and diffusion behaviors, using Kendall’s tau (τ), for participants in the poultry-keeping workshop. All coefficients reported in the table were positive. Four of the six had large magnitudes (greater than .50), and the other two were in medium range (greater than .30). These correlation-sizes point to moderate to strong positive relationships between the research participants’ adoption and diffusion decisions and between their rates of success in both areas of activity.

Table 2

**Correlations Between Adoption and Diffusion Behaviors (Poultry-Keeping)**

<table>
<thead>
<tr>
<th>Adopter or non-adopter</th>
<th>Extent of diffusion by # innovations diffused</th>
<th>Extent of diffusion, by est. # who later adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficients</td>
<td>Diffuser or non-diffuser</td>
<td>.54</td>
</tr>
<tr>
<td></td>
<td>τ</td>
<td>.53</td>
</tr>
</tbody>
</table>

*Note.* n = 30.

Table 3 displays Kendall’s tau (τ) correlations for farmers who attended the bee-keeping seminar. The coefficients were calculated on associations between five variables related to post-training adoption and diffusion activities. All six relationships were positive and registered substantial correlation-sizes, with five above, and one approaching, the conventional threshold for large magnitudes. Again, these correlations represent strong to very strong positive relationships among the variables tested. Workshop participants who implemented recommended practices after the training went on to diffuse the same practices to others to a greater extent than those who did not make post-training adoption decisions, or adopted fewer improved practices.
Table 3
Correlations Between Adoption and Diffusion Behaviors (Bee-Keeping)

<table>
<thead>
<tr>
<th>Adopter or non-adopter</th>
<th>Extent of adoption by # innovations adopted</th>
<th>Diffuser or non-diffuser</th>
<th>Extent of diffusion by # innovations diffused</th>
<th>Extent of diffusion, by est. # who later adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tau )</td>
<td></td>
<td>.78</td>
<td>.65</td>
<td>.60</td>
</tr>
</tbody>
</table>

Note. For adoption data, \( n = 28 \); for diffusion data, \( n = 24 \).

Conclusions

Although caution would be necessary when considering whether to apply these findings to other populations, they served to suggest potentially productive directions and points of focus for subsequent research. Farmers across the samples who exhibited higher levels of adoption of workshop-recommended innovations also had a moderate to strong likelihood of showing correspondingly higher levels of diffusion-related behavior. These conclusions agree with Rogers (2003) in his discussion of change-agent credibility. His research indicated that prior personal adoption of an innovation increases a person’s credibility as a persuader with other potential adopters, and thus increases the likelihood of success in efforts to diffuse the innovation among network members.

Feder and Slade (1984) applied diffusion theory to the spread of agricultural innovations among Indian farmers and also concluded that one of the key factors was farmers who, having already adopted a new practice, influenced other farmers in their community likewise to implement it until a majority had done so. Bandura (2006) emphasizes the roles of social modeling and perceived self-efficacy as predictors of human decision-making behavior. Adopters of the improved agricultural practices recommended by the seminar trainers became social modelers of those innovations, thereby exerting a persuasive influence on others in their networks. This seems to have been reflected in the relatively strong correlations between adoption decisions by participants and the associated subsequent adoption of the innovations by others. In the social cognitive framework, one of the results of social modeling is to increase personal self-efficacy beliefs.

Thus, social modeling not only exerts persuasive influence on potential adopters in terms of the demonstrated benefits of the innovation, but also serves to increase their self-efficacy beliefs, which further raises the likelihood of making a decision to adopt. Again, this corresponds well with the associations observed between the adoptive and diffusive patterns exhibited by the farmer-participants at the Twiga seminars.

Implications

Although the rates of adoption and diffusion by the workshop participants varied widely across the entire number of recommended practices, the grand mean percentage of those who diffused to others at least one improved practice from a seminar was 54.19%. There are, of course, many other factors to consider in the
comprehensive evaluation of a training event, but these percentages provide some evidence for the effectiveness of the Twiga workshops in training farmers who diffuse innovations to other community members. One implication to identify tentatively from this rate of trainee dissemination of recommended practices is that such seminars—planned, hosted, and conducted by local leaders in partnership with qualified instructors—can be an important component in an overall strategy for community-focused agricultural development. Opportunities for cost-sharing and for the creation of new, long-term partnerships with both governmental and nongovernmental agencies are only two of the auxiliary benefits that could be listed. Among the most important is the financial empowerment of farmers who receive training and implement innovative practices. One farmer who attended the bee-keeping workshop, because of the training and a personal contact made at the seminar, was able some months later to sell his honey and pay his child’s school fees with the proceeds.

A second implication relates closely to another of the central purposes of this study—to contribute to a better understanding of the ways in which Twiga-area farmers, after community-based seminar training, could serve as informal change agents in diffusing agricultural innovations. This implication is that many of the participants in the three Twiga seminars appeared to function in a kind of informal-change-agent role, distinct from the full-fledged change agents, the para-professional aides, or even the opinion leaders whom Rogers (2003) described at some length in his chapter on change agents. There were recognizable change agents, aides, and opinion leaders present occasionally or residually in the Twiga community. Most of the participants in this research, however, did not fit neatly into those categories, and yet many of them were quite active in diffusion-related activity. Toward the end of his discussion of change agents, Rogers (2003) included a section describing centralized and decentralized diffusion systems. In the process he made this observation regarding the latter type: “In many cases, adopters served as their own change agents in diffusing their innovations to others” (p. 395). Although Rogers did not use the words “informal change agent” in this context, his reference to some adopters in a decentralized diffusion system functioning “as their own change agents” makes the descriptor seem appropriate.

Conventional change agents are somewhat handicapped in their role by the heterophily that comes with being outsiders. Informal change agents, whose roots and residences are in the same community in which they seek to diffuse innovations, have high homophily and little or no heterophily within their local networks. They are thus ideally suited to bridge between “outsider” change agents and “insider” potential adopters. In the Twiga community there was some overlap between opinion leaders (the diffusion-of-innovations term) and these informal change agents, but many of the latter did not fit Rogers’ description of opinion leaders. Informal change agents who are members of one or more networks within the community—such as, for example, a farmers’ group and/or a church congregation—may have useful combinations of strong- and weak-ties networks that facilitate both horizontal and vertical dimensions of diffusion. This is a notable instance of theoretical territory shared by two distinct models: Diffusion of Innovations and Social Network Analysis (Kadushin, 2012).
Recommendations for Practice and Research

One recommendation for practice is that farmers who adopt improved practices learned in training be identified specifically for further interventions related to implementation and diffusion of agricultural innovations. As an example of the need for this sort of intervention, early-adopter trainees often cannot afford to purchase improved hives and the protective and processing equipment needed for profitable bee-keeping. If these farmers could access low-interest loans, they would be more likely both to extend their adoption of recommended best practices and also to disseminate these innovations to others.

Second, it is recommended that agricultural seminars continue to be offered periodically at Twiga and in neighboring areas, and that conducting this kind of local workshop be initiated in rural communities where it has not been done before. When asked in follow-up interviews about the primary factor that influenced them to adopt an improved practice, a large majority of research respondents selected seminar participation. Davis (2004), after research on farmers’ groups in Meru, Kenya, made a similar recommendation: “Provide capacity building in the form of training, cross-visits, agricultural shows and other mechanisms to build the capacity of farmers and groups” (p. 212). This type of training event, with a typical interactive and hands-on format, is an excellent way to equip informal change agents and to sensitize them to their potential role in the diffusion of developmentally crucial practices in their networks. Bandura (1982) cited experiences such as farmers go through during these workshops as significant ways to increase self-efficacy, and thereby to achieve desired changes in one’s environment.

For further research, a first recommendation is to extend the analysis of the data used in this study by focusing on the minority of trainees who participated in two or in some cases all three of the seminars at the demonstration farm. What, if any, were the effects of their exposure to multiple iterations of training during a three-month period? Did they adopt improved practices more comprehensively or more rapidly than those who attended only one workshop? Did they disseminate to others more widely and effectively?

Bandura (2002, 2006b) argued at some length that the central construct of self-efficacy beliefs in social cognitive theory transcends cultural differences: Research testifies to the cross-cultural generalizability of self-efficacy theory….Not only is the structure of self-efficacy beliefs comparable cross-culturally, but so are their functional properties. Regardless of whether the culture is American, Italian, Korean, or Chinese, the stronger the perceived self-efficacy, the higher the performance attainments (2006b, p. 175).

A second recommendation, then, for further research is to test this assertion about the cross-cultural functionality of self-efficacy beliefs in an East African context, and specifically in regard to the significance of self-efficacy as a predictor or explanatory factor with diffusion behavior by informal change agents. This researcher has not found any comparably detailed discussion of claims that the Theory of Personal Behavior and Social Network Analysis models are also robust in cross-cultural applications, but both of them have also been used in studying behavioral change and social-network issues in a variety of cultures (Hagger, Chatzisarantis, Barkoukis, Wang, Hein, Pihu, Soós, & Karsai, 2007; Ndah, Schuler, Uthes, & Zander, 2010; Parkhe, Wasserman, Ralston, 2006; Pavlou & Chai,
2002; Wilson, Zenda, McMaster, & Lavelle, 1992). It is recommended that studies be designed and conducted for the purpose of assessing the utility of these models for cross-cultural behavior-change analysis in general, and for diffusion of innovations in particular. Perhaps it would be advisable to begin with a meta-analysis of both frameworks to survey as many examples as possible in which they have been used in cross-cultural research.

A final research recommendation is to use the results of the present study as beginning points for other studies that may extend, confirm, or disconfirm these results. The criterion-variable correlations found to have small-to-medium and larger magnitudes could be explored further with random samples of farmers. Regression or factor analysis could be used to go beyond the initial correlational analysis and move toward explanations of outcomes that might permit generalization of results beyond the research samples. There is room not only for additional quantitative studies to extend or modify the findings of this research, but also for qualitative and mixed-methods approaches. It is expected that these diverse strategies will contribute significantly to empirically based knowledge about how East African farmers can work toward food security and overall improved livelihood as an attainable goal.

References


Abstract

Previous studies have shown that there is not one universal set of factors that contribute to smallholder farmers' adoption of Conservation Agriculture. However, network influences at the local and regional levels play a key role in innovation and technology diffusion. A major challenge in research dedicated to measuring these influences is representing farmer network structure. Mixed methods baseline and endline surveys on adoption of Conservation Agriculture and farmer information sources were carried out in 2010 and 2014 in Molo, Uganda (n=92), Kween, Uganda (n=94), and Kitale, Kenya (n=65). Network structure is explored at multiple levels: the meso-level, where agents serve as sources of vertical knowledge; and the micro level, where farmers spread new technologies horizontally, often through involvement in farmer groups and associations, and integrate them into existing local knowledge. The survey results indicate that farmers understood the three principles of Conservation Agriculture as independent concepts and that crop rotation is widespread. Adoption of minimum tillage increased significantly (p < 0.01) in the Ugandan sites, and knowledge of minimum tillage increased significantly in all research sites.

Keywords: Technology adoption, Conservation Agriculture, social networks, East Africa, innovation diffusion
Introduction

Conservation Agriculture (CA) is increasingly promoted as an improved long-term approach to agricultural production for smallholder farmers, based on three principles: minimum mechanical soil disturbance, permanent organic soil cover, and crop rotation (FAO, 2015). There is a growing interest by major development agencies to further the development of locally-adapted CA production systems in many regions of the world and to promote adoption of CA practices among farmers (Hobbs, Sayre, & Gupta, 2008; Hobbs, 2007; Kassam, Friedrich, Shaxson, & Pretty, 2009; Knowler & Bradshaw, 2007; Marongwe, Kwazira, Jenrich, Thierfelder, Kassam, & Friedrich, 2011).

Knowler and Bradshaw (2007) provide a synthesis of research focused on farmers’ adoption of CA all over the world to identify common variables that explain adoption. They conclude that there do not seem to be any universal explanations of adoption and suggest that future studies should focus more on the circumstances of local and regional stakeholders in the promotion of CA. Taking this into account, we share our findings from a study in which we explore farmers’ agricultural information networks in three sites in Kenya and Uganda at two different points in time. We focus on the ways that information reaches farmers and the key relationships that promote innovation diffusion rather than on individual farmer attributes (such as socioeconomic status and education) that might contribute to their decision to adopt or not adopt CA.

Theoretical Framework

Previous research in the Mt. Elgon district of western Kenya and eastern Uganda indicates the importance of community support networks in facilitating a mindset change towards CA principles (Moore et al., 2012). Growing recognition of the instrumental role social networks play in effecting widespread adoption of new technologies increasingly challenges the conventional “diffusion of innovations” theory, a popular appellation coined by Rogers (2002) to describe the linear model of technology transfer from the agricultural researcher to the local extension agent to the farmer. Wolf (2006) argues that the linear model fails to consider local actors and knowledge, thus rendering it ineffective and inappropriate when applied universally.

Hermans, Stuiver, Beers, & Kok (2013) discuss the need for more studies focused on the roles actors play at the micro level and the intersection between these roles and the innovation systems in which they participate. Hermans et al. (2013) describe a multi-level perspective, in which three different levels of an agricultural system affect innovations and technology diffusion: the micro, meso-, and macro-levels. The authors break down these levels as: “(1) The relatively fast-changing micro level of niches, (2) the stabilizing mechanisms of meso-level regimes, and (3) the slow-changing macro-level of socio-technical landscapes” (Hermans et al., 2013).

This multi-level perspective considers both vertical and horizontal knowledge transmission and innovation diffusion. Vertical, or hierarchical, processes refer to formalized knowledge produced by researchers, adopted into the curriculum of extension agents or the products of agribusiness companies, and transferred to farmers. However, local adaptation of this knowledge requires farmer networks to discuss, test, and evaluate adaptations to the local context, and this creates local agricultural knowledge that is often more relevant to farmers than formal knowledge (Moore, Lamb, Sikuku, Ashilenje, Laker-Ojok & Norton, 2014; Wood et al., 2014).
Such processes at the micro-level constitute Herman et al.'s (2013) horizontal diffusion. Micro level farmer information networks are difficult to fully capture when working across multiple networks. Instead of designing a study to measure exact contact between farmers in dense social networks at the village level, we approximate such networks through shared membership in community groups. Affiliation networks are well-established in the social network literature as a means to studying the role of co-attendance to events and co-membership in groups (Jasny, 2012). Development researchers have argued that the formation and composition of endogenous rural producer organizations and other community-based organizations in Ghana and Ethiopia have important implications for development policies and social network based interventions (Arcand & FaFchamps, 2011; Zeitlin, 2011).

Identifying sub-groups or cliques and then identifying opinion leaders from within those groups has been studied and used in the context of public health promotion, such as in nutrition promotion, safe sex behaviors, and tobacco prevention (Valente & Fosados, 2006). Community groups have been associated with HIV prevention strategies in Zimbabwe (Erbaugh, Donnermeyer, Amujal, & Kidoido, 2010), and Farmer Field Schools have long been established as conduits for farmer-to-farmer information exchange in agricultural development (Erbaugh et al., 2010; Simpson & Owens, 2002).

CA is the ideal technology to study networks of stakeholders and their roles in developing and spreading innovations for three reasons: it is a controversial technology, it must be adapted to local agro-ecological zones, and its dissemination occurs over the course of years.

The most controversial aspect of CA is the tenet of minimum soil tillage. Conventional tillage and increased mechanization has traditionally been associated with weed control and progress in agriculture (Triplett & Dick, 2008), and conservation tillage has historically been met with some reluctance and skepticism by farmers (Bultena & Hoiberg, 1983). This element of resistance and perceived risk means that a farmer's decision to adopt a minimum- or no-till system is part of a more complex process than a simple diffusion of information or farm inputs. Additionally, the crops selected to act as organic soil cover in CA systems will vary widely by agro-ecological zone, requiring local actors to serve as innovators in order for CA to become established. Determining the most appropriate cover crop in a specific agro-ecological zone may take more than one season, and it may take multiple planting seasons before late adopters are convinced to implement CA on their land. Disadoption or abandonment of CA practices may occur at any point after initial adoption of the technology.

**Purpose and Objectives**

We discuss farmer information networks in Kenya and Uganda using horizontal, or micro level, and vertical, or meso-level, diffusion processes as an analytical framework. We show that farmers seek agricultural advice as much from local contacts, such as neighbors and endogenous community group leaders, as from contacts at the meso-level, such as private agro-input vendors and extension agents. Additionally, we discuss the interaction between these two levels within the local context.

We also measure adoption and disadoption of CA between a baseline and endline survey in Kenya and Uganda and find that adoption rates increased significantly in the Uganda sites between 2010-2014, and we discuss the different ways that farmers learned about the
technology within vertical and horizontal networks.

Methods
Baseline data collection
The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) Long-Term Research Activity in East Africa conducted research on CA among farmers in the Mt. Elgon region of western Kenya and eastern Uganda. As part of that research, farmers and service sector/community agents were interviewed and data collected on their beliefs about CA and on the structure of their agricultural information and resource networks using a mixed methods approach combining focus group and key informant interviews with a formal survey of using standardized questionnaires (Moore et al., 2012).

The sampling methodology for the formal survey baseline data used in this study is described in detail in Moore et al. (2012). Briefly, in Uganda, farmers were selected from Kidoko and Kipangor parishes in Molo subcounty and from Kere and Kwosir parishes in Kween (formerly part of Kapchorwa) subcounty. On-farm demonstration gardens were established in each of the parishes in partnership with landowners. In Trans-Nzoia District, Kenya, the peri-urban populations of the Kibomet and Milimani sublocations were selected for the study. A list frame was created by obtaining records of household heads from each subcounty or sublocation and then by performing a stratified random selection from each list. Substitutions were made in the field when households could not be located. In each site, mixed teams of 2-3 men and women were employed as enumerators to ensure familiarity with the local language and geography, and a local community leader was hired as a guide to introduce the research team and to coordinate interviews. The survey instrument was developed in close collaboration with Ugandan NGO partners who were familiar with the local languages and with administering surveys in the area. Many questions from the baseline survey were included in the endline survey instrument to measure adoption between the two time points. Then, the survey instrument was tested on 10 individuals, who gave detailed feedback about their interpretation of each question. Once the survey instrument was finalized, the enumerators were trained for one full day at each site to ensure consistency and credibility. As part of the training, enumerators practiced administering the survey to one other in English while being monitored for any inconsistencies. The teams of enumerators conducted the first three surveys at each site as a group to ensure that the questions were being asked in a uniform way. A member of the research team sat in on the administration of every survey.

During the administration of the surveys, measures were taken to ensure the construct validity of the variables used to measure the adoption of CA practices. If participants responded affirmatively to a question about the adoption of a CA practice such as minimum tillage, they were also asked follow up questions about the percentage of land on which they implemented the practice, the year in which they began practicing it, and the reasons for which they chose to practice it. If it became clear through their qualitative explanations that they had not understood the adoption question fully, the question was revisited.

Surveyed individuals identified their contacts for agricultural information, advice, and resources from a list of occupational categories that was created from a position generator during focus group interviews with local stakeholders and farmers (Moore...
et al., 2012). The position generator method asks respondents about their relationships with members of specified occupations, which in this case were service sector and community agent occupations related to agricultural production and community engagement, such as extension agents, market vendors, and religious leaders (Lamb, Mills, Moore, & Alwang, 2011). Between eighteen and twenty-two of these agents were identified in each site. Those agents from the occupational categories who were identified by more than five respondents were then interviewed in a snowball sample. The service sector and community agent categories that were identified included government extension agents, vendors in agro-vet shops, leaders of farmer groups, and local political leaders. This sampling methodology allowed for a detailed representation of agricultural networks beyond the village level.

**Endline data collection**

For the endline survey, we resurveyed the households that were interviewed for the baseline survey and conducted another round of interviews with key informants. The survey instrument for the endline survey replicated questions about the structure of farmers' information networks and also included questions about farmers' adoption of CA practices. All households from the baseline survey in Molo, Uganda (n=92) and in Kween, Uganda (n=94) also participated in the endline survey, but there was a 20% attrition rate in Kitale, Kenya (n=65). During the endline survey, respondents also answered questions about their membership in community groups, such as farmers' groups, savings groups, women's groups, and youth groups. Using the names of the groups to which each respondent belonged, we created one-mode and two-mode affiliation networks for each site to estimate farmer-to-farmer contact at the micro level (Jasny, 2012).

**Network Construction**

Two distinct types of networks were constructed using the data: directional farmer contact networks at the meso-level with service sector and community agents; and bipartite, or two-mode affiliation networks that depict farmers and the community groups to which they belong at the micro level. The network graphs are directional. Nodes represent the respondents and the service sector/community agent categories, and edges were determined from respondents' information and resource contacts: “Do you exchange physical resources with [occupational category] such as seed, fertilizer, or cash, information about agriculture, or both?”

The relationships are directional because the service sector/community agents who were identified by name by more than five respondents were interviewed about their roles in promoting agricultural technologies and their attitudes towards CA practices, but since many of them served in a more formal role at the subcounty level, they could not identify all of the specific farmers with whom they exchanged information. The extension agents, for example, held trainings and field days with many groups of farmers at once across several different subcounties.

Often, local leaders served in several roles and were known more for one role over another by different respondents. For example, religious leaders also often worked as schoolteachers. Veterinary service providers sometimes had agro-vet shops of their own. Farmer groups and organizations often functioned as savings groups or women's groups as well. In some cases, respondents listed individuals in the “Other” categories who actually held formal roles, such as leaders of savings groups or village
chief, but the respondent knew the person they listed in another capacity outside of that role. Additionally, respondents did not identify contact with a certain category if they themselves fell into that category. For example, a respondent from the original random sample who happened to be a farmer group leader did not answer questions about her or his contact with “Leader of farmer group”, as a category. Due to this, some categories were likely underreported.

Bipartite graphs, or two-mode affiliation networks, were constructed using data on membership to community groups. Respondents were asked: “Are you an active member of any groups, organizations, or associations? Please list all and specify the type of group (farmers', women's, savings, youth, health, etc.)”. The group names were standardized and affiliation edge lists were created from the data. All network graphs were built in Gephi using the Force Atlas 2 and Fruchterman-Reingold algorithms (Jacomy, Venturini, Heymann, & Bastian, 2014).

The three principles of CA (minimum mechanical soil disturbance, permanent organic soil cover, and crop rotation) are often understood and promoted separately. Even producers who are familiar with each of the principles individually may not have a good concept of Conservation Agriculture as a coherent technological package. Because of this, survey respondents answered the same set of questions about each of the principles.

In the baseline and the follow-up survey, producers were asked if they had heard of minimum tillage and if they practiced it on any portion of their land. Project participants had established demonstration gardens in each of the sites in 2010 to measure the agronomic effects of a CA system in each agro-ecological zone. The primary focus of the project was collecting agronomic measurements rather than on outreach, but some educational meetings were held early on to discuss the potential merits of adopting a CA system. The survey included questions on disadoption as well as adoption of CA practices, as farmers who have disadopted the technology can help researchers better understand the barriers to adoption that farmers face in a specific area (Giller et al., 2011).

**Results and Discussion**

**Meso-level network structure**

Table 1 lists the five service sector and community agents from each research

![Figure 1. Top in-degree contacts in Kitale, Kenya (2010).](image-url)
site that had the highest in-degree at the time of the baseline and endline surveys. Figures 1 and 2 visually depict the farmer information network structures in Kitale, Kenya in 2010 and 2014. White nodes represent farmers, and colored nodes represent service sector and community agents. Larger node size indicates larger in-degree centrality. The lines, or edges, between farmers and community agents represent a relationship between the two nodes connected by them. During the period of four years, we would not expect the structure of participants' social networks to remain static. Service sector or community agents who hold a prominent role may not maintain that role. Non-governmental Organizations (NGOs) may implement

Table 1. The five service sector and community agents with the highest in-degree centrality in each research site.

<table>
<thead>
<tr>
<th>Position</th>
<th>Molo</th>
<th>Kween</th>
<th>Kitale</th>
<th>Molo</th>
<th>Kween</th>
<th>Kitale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Other farmers</td>
<td>Other farmers</td>
<td>Agrovet</td>
<td>Agrovet</td>
<td>Other farmers</td>
<td>Agrovet</td>
</tr>
<tr>
<td>2</td>
<td>Vet</td>
<td>Vet</td>
<td>Vet</td>
<td>NGO</td>
<td>Extension</td>
<td>Vet</td>
</tr>
<tr>
<td>3</td>
<td>Extension</td>
<td>vendor</td>
<td>farmers</td>
<td>Farmer group leader</td>
<td>Religious leader</td>
<td>Extension</td>
</tr>
<tr>
<td>4</td>
<td>Agrovet</td>
<td>Agrovet</td>
<td>Tractor owner</td>
<td>Farmer group leader</td>
<td>Religious leader</td>
<td>Extension</td>
</tr>
<tr>
<td>5</td>
<td>Mkt. vendor</td>
<td>Mkt. vendor</td>
<td>Extension</td>
<td>Extension</td>
<td>Politician</td>
<td>Political</td>
</tr>
</tbody>
</table>

Figure 2. Top in-degree contacts in Kitale, Kenya (2014).
intensive short-term projects in an area but change locations entirely once the project has come to a close. Political leaders may play a larger role in information dissemination and resource distribution while running a campaign. Agrovet and agricultural inputs shops may close or change locations.

Indeed, Table 1 provides evidence that survey respondents had different agricultural information and resource contacts in 2014 than they did in 2010. Just over half of the highest in-degree categories in 2014 do not appear in the top categories for 2010. Some contact categories do maintain their position, such as the agrovets and vets in Kitale, Kenya. In Kween, Uganda, farmers identified “Other farmers” as an agricultural contact more often than they identified any actor with a formal role.

Important to note is the role of the private vendors as sources of agricultural information. The “Agrovet” category appears in the top five highest in-degree centrality nodes in all but one of the surveys. This category may refer to small agricultural input shops located within the village, but it was also interpreted as agrovet or input shops in nearby towns that serve clients from several villages. Some agrovet shops are run by just one individual or family, but others, such as the majority of the agrovet shops in Kitale, Kenya, have over ten employees. Because of this, it was sometimes difficult to distinguish between the “Urban vendor” and “Agrovet” categories during the data collection process. Collectively, the “Agrovet”, “Urban vendor”, and “Weekly market vendor” account for 40% of the highest in-degree contacts in 2010 and 26% in 2014. Farmers visit local stockists and agrovet shops to purchase agricultural inputs but also to learn about new technologies. Larger agrovet shops, such as those in Kitale, hold seasonal field days in which they act like extension agents and visit the surrounding villages to promote a certain seed variety, chemical, or other input. In Molo, Uganda, a local agrovet had established an information center at his shop and received daily text messages about market prices.

Micro level network structure

The in-degree measures show that farmers value the information and advice of other farmers and community leaders as well as the information they get from more formal sources. In recent studies on social networks among groundnut growers in Kenya and Uganda, Thuo et al. (2013; 2014) found that local farmer groups and associations were deeply embedded in social network structures and that the majority of
farmers were involved with at least one group or association. The data from this study confirms that farmers had high rates of participation in groups, as shown in Figure 3. In Molo, Uganda, 92% of respondents to the endline survey belonged to at least one group or association. Overall participation rates are lower in Kween, Uganda, and Kitale, Kenya, at 66% and 48%, respectively, but still high enough to suggest that farmer and community groups are important components of farmer information networks in these sites.

Local savings groups, by their nature, require an elevated level of trust between individuals. During each meeting of groups that save together, individual farmers contribute small amounts of money to their group fund. Eventually, when the group has saved enough money, it can invest in something that is likely to raise the income of the whole group, such as a cow. The income the groups gain through milk sales is put back into the group fund to eventually purchase more cows or participate in other income-generating activities. The savings activities, in many cases, take place completely within the village and lack any sort of external accountability. Other groups, such as Farmer Field Schools and growers' associations, typically have some sort of outside influence, at least at their inception. In Uganda, the national Extension agency encourages farmers to form groups and associations. Farmer Field Schools are often formed in partnership with NGOs or Extension agents. Larger producer organizations with corporate connections, such as to national brewing companies, are sometimes involved in the formation of smaller farmer groups. For example, since barley grows well in Kween, Uganda, a Ugandan brewing company visited the area and encouraged farmers to form a growers' association and grow barley together. Farmer group leaders play a pivotal role in the micro and meso-levels of horizontal and vertical farmer information networks. Hermans et al. (2013) use the term “innovation brokers” to refer to individuals who facilitate linkages between different levels of the agricultural system. In this case, farmer group leaders can be considered innovation brokers, connecting the vertical and horizontal diffusion processes. They help identify farmers that fit specific criteria.

Figure 4. Bipartite graph of farmer groups and associations in Molo, Uganda in 2014.
to qualify for Extension and NGO resources and programs, but they also coordinate endogenous savings and agricultural activities within the group.

Thuo et al. (2014) argue that interventions to improve agricultural productivity should involve participatory work with local groups and associations. Our findings in the Meso-level network structure section on farmers' preference for other farmers and farmer group leaders as advice contacts support this conclusion. Key farmer groups and their leaders may serve as important intervention points at the nexus between vertical and horizontal innovation diffusion. Understanding the structure of community groups in an area would be a useful part of a baseline survey for stakeholders interested in promoting a technology such as CA at the micro or village level. Figure 4 illustrates the network of individuals connected by savings, women’s, and farmer groups in the Molo research sites. Small nodes represent farmers, and the larger, labeled nodes represent the groups to which they belong. The two most active groups with the highest degree were the Karwok Farmer Field School and the Post Test Club (labeled). While several of the groups pictured in the periphery had only one member in the study sample, others were densely interconnected, with members who were involved in several different groups. The structure of the affiliation network in Figure 4 suggests that identifying the largest farmer and savings groups in Molo could be a useful strategy for determining intervention points to promote a farming technology such as CA. Farmers will often wait to adopt a perceived risky or abnormal behavior, such as changing one’s way of farming, until they see that their peers have been successful with it (Udry & Conley, 2004), or until the innovation diffuses throughout their producer (horizontal) network (Isaac, 2012). If leaders and members from the central groups are included in co-innovation processes, they may be more likely to involve or inform their fellow group members. However, if closed trainings are held or physical resources are given to members from only one farmer group or association and not to others, members from peripheral groups may feel alienated or be deterred from becoming involved themselves. The formation of a consortium of group leaders or representatives from a variety of groups in Molo could be a useful strategy for extending the reach of a single outside agent, such as a development or extension agent. In Kween, high participation rates in community groups suggest that such groups may be viable intervention points for regional and national agricultural and development agents, but the lack of interconnectivity between the groups indicates that more leaders may need to be
involved to reach the many smaller isolated farmer groups.

The relatively simple and straightforward data collection process for an affiliation networks study makes it a viable tool for determining network structure at the micro level. Better knowledge about the structure of local networks and the identity of innovation brokers would allow extension and development agents to tailor their programs to be more participatory, inclusive, and effective.

### Adoption of Conservation Agriculture

A variety of factors may have contributed to significantly higher adoption rates of minimum tillage between the baseline and endline surveys, but the rates of farmers practicing crop rotation and cover cropping remained largely unchanged over the study period.

The baseline survey did not include questions about farmers’ use of crop rotation because it was thought to already be a common practice. The follow-up survey confirmed this: 99% of farmers in Molo, 94% in Kween, and 79% in Kitale practiced crop rotation. Qualitative responses revealed a widespread understanding that rotating crops leads to increased soil fertility, pest and disease control, and higher yields. Other reasons respondents listed for practicing crop rotation included to increase food security, to get income from short-season crops, and to minimize weeding.

No significant increases in adoption of cover cropping ($p > 0.05$) occurred between the two surveys. There are several reasons for this. One goal of the demonstration gardens was to determine the appropriate cover crop for each agro-ecological zone. Seeds for the cover crops that were chosen (macuna and lablab) were often not locally available. Some farmers also listed the size of their land as a limiting factor. Fewer respondents had heard of cover cropping than of minimum tillage.

In both of the Uganda sites, an exact McNemar’s Test ($p < 0.01$) determined that there was a significant increase in adoption of minimum tillage among survey participants between 2010 and 2014. In the Kenyan site, adoption of minimum tillage did not increase significantly among survey respondents ($p > 0.01$). The number of survey participants who had heard of minimum tillage increased significantly between the data collection points in all sites ($p < 0.01$). In Molo, Uganda, only 4 of the 61 respondents who had not heard of minimum tillage in 2010 still had not heard about it in 2014. Of those farmers who had

<table>
<thead>
<tr>
<th>Adoption measure</th>
<th>Molo, Uganda ($n=92$)</th>
<th>Kween, Uganda ($n=94$)</th>
<th>Kitale, Kenya ($n=65$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heard of min. tillage (%)</td>
<td>86 (93%)</td>
<td>84 (89%)</td>
<td>46 (71%)</td>
</tr>
<tr>
<td>Adopted min. tillage (%)</td>
<td>30 (35%)</td>
<td>28 (33%)</td>
<td>15 (33%)</td>
</tr>
<tr>
<td>Mean ($s$) years implemented</td>
<td>2.6 (1.4)</td>
<td>2.1 (1.1)</td>
<td>3.7 (2.5)</td>
</tr>
<tr>
<td>Disadopted min. tillage (%)</td>
<td>11 (12%)</td>
<td>12 (13%)</td>
<td>6 (9%)</td>
</tr>
</tbody>
</table>

*Note.* Participants who reported adoption of minimum tillage on some or all of their land were then asked to self-report the date they began implementing the practice. The table above reports the average time between minimum tillage implementation and the time of data analysis for each site. Standard deviations are presented in parentheses.
adopted minimum tillage and were practicing it at the time of the second survey, those in Molo, Kween, and Kitale had been practicing it for an average of 2.6 years, 2.1 years, and 3.7 years, respectively. Those farmers who have disadopted can also play an important role in shaping local knowledge about the technology and perhaps blocking horizontal diffusion. Nine to twelve percent of farmers in each site who were not practicing minimum tillage at the time of the second survey had practiced it in the past and stopped. The most commonly listed reason for disadoption in the Uganda sites was the expense of the herbicide. In Uganda, farmers usually understood minimum tillage as a system where herbicides were used to kill weeds instead of tillage. Since ploughing the land is expensive (three times more expensive than the cost of herbicides in these research sites), minimum tillage is promoted by NGOs and local media sources as a money-saving technology. However, because most farmers who adopted minimum tillage only did so on a portion of their land, they end up paying for both herbicides and ploughing and thus perceive it as an expensive or cost-prohibitive technology. Additionally, the benefits of minimum tillage may not be immediately evident (Giller, Witter, Corbeels, & Tittonell, 2009), which may contribute to farmers’ decisions to cease the practice after initially trying it out. Indeed, some farmers listed their reason for disadopting as “failed to see benefit”.

To address these barriers to adoption, those promoting CA or minimum tillage should be sure to educate farmers on the long-term benefits of the technology and on the other principles of CA besides minimum tillage that help to limit weed growth. The take-away message should not be strictly that herbicides save time and money, but that they can be incorporated into an agricultural system that can help to mitigate soil erosion and other harmful effects of farming activities, especially for smallholder farmers who have few acres for themselves and their families. Many farmers misunderstood minimum tillage to be ploughing the land almost as much as they usually would and then also spraying herbicides, which would indeed increase the overall cost of production. If CA and/or minimum tillage is to be promoted as a money-saving technology, its proponents must preemptively address this common misunderstanding.

Minimum tillage is a relatively new concept in Kenya and Uganda (Moore et al., 2014), but farmers are learning about it from contacts at the meso- and micro levels and from local media. In Kween, Uganda, farmers who had heard of minimum tillage were asked where they heard about it. Of the 66 farmers who responded to this question, 44% heard about minimum tillage from other farmers or neighbors, 20% from radio or other media, 18% from the local demonstration plots of the NGO that was promoting CA, and 18% from various other sources. This supports the findings of Thuo et al. (2013), who found that farmers in Kenya and Uganda utilized demonstration plots and media as sources of agricultural information, but more often sought information from informal strong ties within their networks and village meetings. Indeed, “Other farmers” as a category appears frequently in Table 1 as a high in-degree node.

Since information about minimum tillage is coming from multiple sources, farmers are likely getting mixed messages about how best to implement it. This is important for those promoting CA and/or minimum tillage in the region to consider, since it could be confusing to farmers. One way to mitigate this potential problem would be to hold small-scale periodic surveys with farmers who are not involved in any
demonstration garden or training activities to learn about farmers' knowledge of the CA and/or minimum tillage, instead of the traditional approach of one large baseline and one large endline survey.

Additionally, we considered whether respondents belonged to a farmer group that had outside influence (such as from Extension, an NGO, or the private sector) or not and whether respondents had adopted minimum tillage or not. Using Pearson's Chi-squared test and Fisher's Exact test, we found that there was no significant relationship between the outside influence of a group and adoption of minimum tillage ($p > 0.05$), providing further evidence that the combination of both formal (vertical) and informal (horizontal) diffusion processes are critical to the spread of the technology.

**Conclusions**

Since farmers access information through multiple knowledge sources, they often receive mixed messages about the principles and implementation of Conservation Agriculture. By focusing on the structure of farmer information and technology networks at the micro and meso-levels, we gain important insights into elements of vertical and horizontal knowledge transmission processes in three sites in Kenya and Uganda. A diverse group of agents at the meso-level serve as formal sources of agricultural information for village level networks, where horizontal diffusion then takes place as farmers adapt technological advances according to local knowledge. Sources of vertical knowledge go beyond Extension agents and agricultural NGOs to include private vendors, religious leaders, local politicians, and farmer group leaders, and the structure of farmer information networks at the meso-level changes over time. Affiliation networks are a seemingly underutilized tool for estimating farmer networks at the micro level through shared group membership in farmers', savings, and women's groups. Such groups play an important role in the intersection between vertical and horizontal knowledge exchange and innovation diffusion. Studies of affiliation networks by farmer group membership could be used to quickly identify local agricultural knowledge hubs and understand network structure at the micro level, and the methods and findings from this work could inform future studies on the diffusion of a technology such as CA through networks of smallholder farmers.

**Acknowledgments**

We would like to thank our SANREM CRSP partners at AT Uganda for their guidance and logistical support: the late Susan Mugala, Ketty Nambozo, and David Chemusto. We acknowledge Jeni Lamb's contribution of baseline data collection and previous work. We also acknowledge the contributions of the SANREM CRSP team at University of Wyoming and in Kenya and Uganda: Dr. Jay Norton, Dr. Bernard Bashaasha, Dr. Dennis Ashilenje, and Dr. Emmanuel Omondi. We would like to thank Dr. Caitlin Rivers for her guidance and mentorship throughout the research process. Above all, we would like to thank the many farmers in Molo, Kween, and Kitale who volunteered their time to participate in this study.

**References**


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**Diffusing Water Conservation and Treatment Technologies to Nursery and Greenhouse Growers**

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**Abstract**  
Nursery and greenhouse operations require significantly large amounts of water to maintain product quality and often use more than what is needed by the crop being grown. The nursery industry’s use of water is highly criticized and adds to arguments against agricultural water use with increasingly limited water resources available globally. The purpose of this study was to explore the barriers and motivators associated with nursery and greenhouse growers’ adoption of water conservation and treatment technologies. In-depth interviews were conducted with 24 operators across the U.S. to identify their perceptions of new water-saving technologies and treatments based on the five attributes of an innovation identified by Rogers (2003). The findings revealed growers are aware of water-saving technologies and the rate of adoption depends on a variety of factors including: perceived cost, lack of ability of their workforce to use the new technology due to its complexity, and belief that their product will be worth more if it is grown in an environmentally-friendly manner. Barriers to adoption included the high cost of replacing equipment, incompatibility with existing systems, and the perception that new technologies do not fit in with the traditional hands-on approach to horticulture. Suggested extension programs to reach growers include developing materials that highlight the economic benefit of adoption and cost recovery, YouTube videos that reduce issues with perceived complexity growers can use with their workers, and programs that emphasize how technology fits in with the culture of the horticulture industry.

**Keywords:** adoption, water conservation, water treatment, diffusion, technology, nursery and greenhouse industry

**Acknowledgement:** This research is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2014-51181-22372.
Introduction

It is predicted that by 2030 the world will face a 40% global water deficit (2030 Water Resource Group, 2009) “under the business-as-usual scenario” (UNESCO, 2015, p. 11) due to urban and economic development. Water scarcity significantly threatens the nursery and greenhouse industry (Kratsch, Ward, Shao, & Rupp, 2010) with the need for industry engagement in water-saving techniques described by Mezzitt (1992) as an “international challenge requiring local solutions” (p. 82). Fortunately, water conservation efforts are expanding. Schaible and Aillery (2012) found more than two billion dollars were invested in new agricultural irrigation systems that conserve water between 2003 and 2008 within the nursery and greenhouse industry. In the U.S. alone it was estimated that between 2006 and 2013 nearly 760 billion gallons of water were conserved due to alterations in agricultural irrigation systems within the industry (USEPA, 2014). Unfortunately, those water savings are not enough to overcome future demand and efforts must expand to ensure a water supply that will meet future demands (Kratsch et al., 2010).

Water conservation technologies such as drip irrigation and soil moisture sensors have been developed to apply water more precisely to crops (Chappell, Dove, van Iersel, Thomas, & Ruter, 2013; Lea-Cox et al., 2013). These innovations allow for efficient irrigation scheduling and are more effective than traditional watering methods (e.g. overhead sprinklers and hand-watering) (Lichtenberg, Majsztrik, & Saavoss, 2013; Mitchell, Shrestha, Klonsky, Turini, & Hembree, 2014). While growers are “positioned in a uniquely environmentally oriented sector of our economy” (Mezzitt, 1992, p. 82) most nursery and greenhouse growers produce a large number of varietals, with varied water use requirements, making it difficult to conserve water by applying the precise amount of water required by each species (Lea-Cox et al., 2013; Regan, 1996).

Although the volume of water and application efficiency are vitally important to conserving water, water quality experts are also concerned about the presence of pathogens and agrichemicals in irrigation runoff from these same operations (Raudales, Parke, Guy, & Fisher, 2014; White, 2013b; Wilson, Riiska, & Albano, 2010). For example, in the U.S. there is a concern that contaminated water could impact plant communities in areas such as the Florida Everglades, the Chesapeake Bay watershed, the Great Lakes Basin, and the San Francisco Bay (White, 2013a; Wilson & Boman, 2011; Wilson & Foos, 2006). Water treatment technologies have been developed to reduce or eliminate possible biological contaminants from water including chlorine gas, sodium hypochlorite, ozone, ultraviolet radiation (UV), copper ionization, and heat treatments (Fisher, Raudales, & Meador, 2010). Not only does the use of these treatments ensure quality water is returned to the natural environment, but recycled water can also be used to irrigate plants, thus reducing fresh water use (Raudales et al., 2014). Despite these concerns, the nursery and greenhouse industry has been slow in its adoption of new treatment technologies that would ensure a quality water supply (Yeager, Million, Larsen, & Stamps, 2010).

It is important that extension professionals help growers overcome barriers to adopting water conservation and treatment technologies (Hartstone, Knight, & Riley, 2006; Heaton, Barnhill, & Hill, 2012; Majsztrik et al., 2013) with water resources becoming more strained and water quality issues increasing (USEPA, 2013). However, the barriers to adoption are largely unknown due to a lack of research in this area. Understanding the barriers to growers’ adoption of water conservation and
treatment technologies can assist extension professionals in developing programs and corresponding educational opportunities that resonate with growers resulting in increased adoption (Huang & Lamm, 2016).

**Theoretical Framework**

The theory of Diffusion of Innovations was used as the overall framework for this study (Rogers, 2003). The specific portion of the theory focused on was the five distinct characteristics of an innovation identified by Rogers (2003) that have been found to directly impact rate of adoption. While there are many other variables such as the type of innovation-decision, communication channels, nature of the social system, opinion leaders, champions of change and the impact of change agents that can impact the rate of adoption, Rogers (2003) identified specific characteristics of an innovation itself that can directly contribute and alter adoption rates. These characteristics were examined in this study to provide recommendations to scientists developing new innovations that appeal to nursery and greenhouse growers and extensionists working to increase the adoption of new scientific innovations. The five characteristics include relative advantage, compatibility, complexity, trialability, and observability of the innovation (Rogers, 2003).

Relative advantage is the perception that the introduced innovation (new technology or practice) is better than what is currently being used or done (Rogers, 2003). Adopters must feel there is an advantage to adoption which may come in the form of financial or social gain as a result of adopting the innovation. Previous research has shown nursery or greenhouse growers are financially driven. Jara-Rojas, Bravo-Ureta and Diaz (2012) found growers were more receptive to the idea of adopting a new technology or practice if the expected outcome was a larger margin of profit.

The compatibility of an innovation is also important. Rogers (2003) emphasized the need for an innovation to work within the current contextual or social system. This means the new innovation needs to work with the technology or infrastructure that already exists but that it must also fit within the social schema of the individual adopting (Rogers, 2003). Chapman, Newenhouse and Karsh (2010) conducted a longitudinal study aimed at increasing adoption of safer nursery crop production practices. Over a three-year period, researchers developed print ads, radio and television commercials, internet materials, and used public events to encourage growers to adopt safety practices. At the conclusion of the study, growers in the target audience did increase their awareness of safety practices; however, the innovative technology was not compatible with some growers’ practices at the time. These growers reported their nursery was too small for the innovation and the safety equipment was of no use for their crops and did not adopt (Chapman et al., 2010).

Rogers (2003) also emphasizes that complexity of an innovation is a major influence on adoption. King and Rollins (1995) conducted a study to identify perceived barriers and possible incentives to assess the usefulness of the pre-sidedress nitrogen test, an agricultural innovation introduced to improve water quality. King and Rollins (1995) found the financial cost and complexity of the soil nitrogen test were the primary barriers to adoption. Llewellyn (2007) noted that adoption of an innovation is often limited by time and the capacity to integrate new, often complex, information.

According to Pannell (1999), trialability was the most important factor in a grower’s decision to adopt an agricultural innovation. Trialability is the ability to try something before actual adoption (Rogers,
Experimenting with an innovation on a small scale allows potential adopters to assess how much risk is involved with the new technology (Rogers, 2003). The risk assessment during the trial phase allows the potential adopter to gain an opinion related to the relative advantage, compatibility and complexity of an innovation (Pannell, 1999). In an effort to understand the factors that influenced the rate of drip irrigation adoption, Alcon, de Miguel and Buron (2011) concluded that farmers who had the opportunity to test drip irrigation technology were more likely to adopt because they improved understanding of the technology through use.

The last characteristic of an innovation, observability, refers to whether or not an individual considering adoption can observe the direct results of its implementation (Rogers, 2003). Chappell et al. (2013) reported three case studies where wireless sensor networks were used by growers to monitor soil moisture and they were allowed to observe the technology in action. The growers observing the use of the technology not only adopted, but expanded their use to include irrigation control because of the value-added benefits of reduced crop cycles, reduced disease pressure and crop loss, decrease in fungicide use, and ability to expand production areas using current water resources (Chappell et al., 2013).

Previous literature shows that the five characteristics of an innovation can have a direct effect on nursery and greenhouse growers’ adoption of specific technologies and treatments related to conserving and protecting water resources. However, research has not been conducted to examine the barriers and enablers associated with the widespread adoption of innovative water-saving technologies and treatments on a broader scale to inform the development of extension programs.

Through a deeper exploration of the perceived characteristics of water conservation and treatment technologies as innovations, stronger (more targeted) extension programs can be created, resulting in increased adoption.

**Purpose and Research Question**

The purpose of this study was to develop an understanding of the barriers and motivators related to nursery and greenhouse growers’ adoption of water conservation and treatment technologies. It was guided by the following research question: How do nursery and greenhouse growers perceive the relative advantage, compatibility, complexity, trialability, and observability of water conservation and treatment technologies?

**Methods**

A qualitative research approach was employed to obtain a deep understanding of nursery and greenhouse operators’ perceptions of water-related issues and to add to the body of knowledge on the topic of water conservation technology engagement. The study was designed to formulate a hypothesis about why nursery and greenhouse operations ultimately adopt or do not adopt alternative water sources and water treatment technologies (DiCicco-Bloom & Crabtree, 2006). An interview guide was developed based on the five characteristics of an innovation (Rogers, 2003) and was created to encourage interviewees to describe the nature of their operation, their role within the operation, and water management decisions. Interview questions encouraged participants to share current water conservation and water treatment activities, explain the water conservation and treatment technologies they were aware of but did not use, and why they chose not to adopt, as well as perceived benefits associated with treating and reusing
A panel of experts made up of academics with specializations in water quality and conservation, water treatment technologies, extension programming, and social science research methods reviewed the interview guide.

Data were collected through semi-structured interviews. Semi-structured interviews were chosen because it allowed the researchers to probe for more information to get a better understanding of the topic (Bryman, 2004). Semi-structured interviews also allowed researchers to ask questions that were not on the interview guide during the course of each interview but ensured the germane research questions were asked at all interviews (Bryman, 2004).

A total of 24 interviews that lasted approximately 90 – 120 minutes were conducted across the U.S. with a targeted group of growers, owners of operations, and upper management personnel with extensive knowledge about water usage at the facility. Interviews were purposively geographically dispersed in regions around the U.S. where crop production operations are densely clustered. Locations were selected in an attempt to obtain maximum diversity and participation nationwide.

To ensure data quality, the interviews were designed to be one-on-one and in-depth for a more personal experience between the interviewer and interviewee, allowing the researcher to build rapport with the interviewee. In qualitative research, building rapport is essential to “establishing a safe and comfortable environment for sharing the interviewee’s personal experiences and attitudes as they actually occurred” (DiCicco-Bloom & Crabtree, 2006, p. 316).

The researcher who conducted the interviews and analyzed the data was a trained social scientist. The interviewer did not have an already established relationship with any of the interviewees and had little knowledge about water conservation technologies prior to initiating the study. While a lack of background in the subject matter area limited understanding of concepts during some of the interviews, it also allowed the researcher to ask descriptive follow-up questions of the interviewee that would have been deemed as unacceptable by someone with in-depth knowledge of the field of inquiry. This allowed for the responses to the semi-structured interview guide to yield unanticipated, nuanced information that the researchers had not anticipated which could then be used to inform future research as suggested by Caplan, Tilt, Hoheisel, and Baugher (2014).

All interviews were recorded and transcribed verbatim. Pseudonyms were assigned to each participant and used throughout content analysis and reporting to ensure participant anonymity. Data were analyzed through content analysis using MAXQDA (v. 12.0.0, VERBI Software, Berlin, GER). Content analysis enabled the researcher to make “reliable, valid inferences from qualitative data” (Krippendorff, 2013, p. 418). Data were stratified a priori (Casullo, 1999) using Rogers’ (2003) diffusion of innovations theory to group data into the five attributes discussed in the preceding theoretical framework section.

Before and after content analyses, the five attributes were reviewed by the researcher to ensure correct identification of themes reducing researcher bias and ensuring rigor (Lincoln & Guba, 1985). The integrity and credibility of the data were maintained by creating an audit trail throughout the entire coding process and formulating a report following review of each interview (Lincoln & Guba, 1985). A peer review of the coding process was completed at the conclusion of data analysis to ensure the data was translated the same by
multiple qualitative researchers (Lincoln & Guba, 1985; Mays & Pope, 1995). Mays and Pope (1995) suggested that one goal of all qualitative research should be to create an account of method and data which can stand independently so that another trained researcher could analyze the same data in the same way and come to essentially the same conclusions; and to produce a plausible and coherent explanation of the phenomenon under scrutiny (p. 110).

The study participants included advisory board members and collaborating growers participating in the Clean WateR³ project. Additional growers (not Clean WateR³ collaborators) were also interviewed to ensure an adequately diverse pool of responses were obtained from which inferences could be made (Table 1). Only two of the participants were female and both women reported using recycled water and water treatment technologies. Only three of the operations were not using recycled water. The operations that were not engaged in using water treatment technologies were primarily in the west and south/southeastern parts of the U.S.
Table 1
Description of Study Participants

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Gender</th>
<th>Geographical Location within the U.S.</th>
<th>Operation uses recycled water</th>
<th>Water treatment used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhonda</td>
<td>Female</td>
<td>Northeast</td>
<td>Yes</td>
<td>Acid and Chlorine</td>
</tr>
<tr>
<td>Edward</td>
<td>Male</td>
<td>Northeast</td>
<td>Yes</td>
<td>Chlorine</td>
</tr>
<tr>
<td>Jason</td>
<td>Male</td>
<td>Northwest</td>
<td>Yes</td>
<td>Chlorine</td>
</tr>
<tr>
<td>Tyler</td>
<td>Male</td>
<td>Northwest</td>
<td>Yes</td>
<td>Chlorine</td>
</tr>
<tr>
<td>Calvin</td>
<td>Male</td>
<td>West</td>
<td>Yes</td>
<td>Chlorine Dioxide</td>
</tr>
</tbody>
</table>
| Frank     | Male   | West                                 | Yes                           | Equipment installed-
|           |        |                                      |                               | “not yet running”                            |
| Herber    | Male   | West                                 | No                            | None                                         |
| Isaac     | Male   | West                                 | Yes                           | None                                         |
| Joseph    | Male   | Southeast                            | Yes                           | Chlorine                                     |
| Phil      | Male   | Southeast                            | Yes                           | Chlorine                                     |
| Richard   | Male   | South                                | Yes                           | Chlorine                                     |
| Brett     | Male   | West                                 | Yes                           | None                                         |
| Greg      | Male   | West                                 | Yes                           | None                                         |
| Adam      | Male   | South                                | Yes                           | Chlorine                                     |
| Lance     | Male   | South                                | Yes                           | Chlorine                                     |
| Katherine | Female | Midwest                              | Yes                           | Hydrogen Dioxide                             |
| Ben       | Male   | South                                | Yes                           | None                                         |
| Daniel    | Male   | South                                | Yes                           | None                                         |
| Jimmy     | Male   | South                                | No                            | None                                         |
| Kenneth   | Male   | West                                 | No                            | None                                         |
| Matt      | Male   | South                                | Yes                           | None                                         |
| Noah      | Male   | South                                | Yes                           | None                                         |
| Robert    | Male   | South                                | Yes                           | None                                         |
| Steve     | Male   | Southeast                            | Yes                           | None                                         |

Results

**Relative Advantage**

Participants perceived irrigation water saving innovations as less wasteful and more advantageous than traditional watering methods. Drip irrigation systems were more “efficient” for water conservation compared to overhead sprinklers (Adam and Frank, interview). Rhonda justified her operation’s use of specific technologies by saying, “We use booms, and sub-irrigation, and [drip], so that [watering techniques] are not wasteful. We don’t have sprinklers [because] it’s not an efficient watering method.” Kenneth provided details regarding the upfront efforts and advantages of using drip irrigation at his operation when he stated, “it's a lot of initial install, but we save on fertilizer, watering time, manual labor all by using the drip irrigation.”

The most common water conservation practice was recycling and re-using water. The recycle and re-use
technique was found to be beneficial for many reasons. Brett explained that his operation recycled and re-used water in order to, “save money, not to let runoff water to the neighbors… and save in electricity.” Calvin revealed his operation’s economic rewards associated with recycling water when he stated, “If we reuse and recycle 150 million gallons of water per year, that’s about $600,000, huge financial benefit. It also provides us with insurance against a disruption in the water supply, and provides us with the additional water that we need to keep all of our acres in production.”

While these technologies were perceived to be less wasteful and more advantageous, the financial costs associated with purchase and installation of water conservation and treatment technologies reduced the relative advantage of adopting the innovation. Phil who still uses overhead irrigation specifically identified “time and money” as a barrier to adopting low flow irrigation. When asked about challenges associated with conserving water at their specific operation, James explained, “a big challenge would be the cost that it takes [to install], and the labor and cost associated with that, as well as direct cost of equipment, whatever, to make it economical.”

Steve affirmed, “Cost is the biggest [barrier] associated with conserving water. I increase my drip production every year, but I never seem to be able to keep pace with it. I’d like to do more.”

Herbert stated, “The biggest challenge is enough capital available to continually improve our irrigation systems.” Herbert went on to explain that large operations with high profits are sometimes not eligible to receive government grants for installation of water conservation technology, specifically “The problem is that we don’t qualify for any financial assistance, to actually install water-saving systems.”

In many cases, the actual treatment process was perceived as a challenge. While explaining the water recycling process, Lance specified, “the same water may be touched three or four times before it goes back out on the plant… the treatment of the water is also an issue.” Edward expressed, “one of the biggest challenges with that is treating that recycled water.” Although viewed as a challenge, the process of treating water is believed to be a necessary step for operations that want to ensure they are irrigating their crops with clean water.

Lance went on to say, “it’s just part of doing business.”

It was found that increased social prestige motivated operators to adopt water conservation practices and treatment technologies. Herbert enthusiastically stated, “we are an environmentally conscious company… there is a certain image that we like to project to our customers that we are doing our share… public image is very important to us.” The social aspect of water conservation was not limited to how customers perceived an operation, but also how operations compared themselves to their counterparts. Richard confidently stated, “We are heads and tails above 99 percent of the people, out there… we can show that we are doing above and beyond what the average person is doing, and contributing to water conservation.”

Stewardship of natural resources was the most frequently mentioned motivator for water conservation. Participants explained that decisions about technology selection were informed by the environmentally conscious nature of their operation. Brett stated “we want to be good stewards of our land because if we didn’t have water and environmental resources, we wouldn’t have a business.” Jason made a similar remark.
when he asserted, “we are stewards of the environment, and that's our biggest motivation.” Jimmy believed bad press associated with how water is managed could lead to a decline in business for the operation. He explained, “we would rather have no publicity than bad publicity. We don’t want to have something running down stream that ends up in the newspaper…” Jimmy also expressed his desire to be the first operation in his locality to have a sustainable water recycling system.

Compatibility
Existing nursery and greenhouse operation designs were associated with barriers of compatibility of newer technologies. Jason expressed his desire to use more micro-irrigation, however the infrastructure of his operation does not permit the implementation of such technology. Jason explained, “we developed the automated system in 1992, and the rest of the nursery was built prior to that time, retrofitting that has been prohibitively expensive.”

Redesigning structures of an operation to make water conservation practices and technologies compatible also emerged from the data. Joseph stated, “From a conversion standpoint, the first step [is] redesigning your nursery to make sure that you can recapture as much [water] as possible...” Katherine described the re-design of her operation to collect water for recycling and re-use purposes. Katherine said, “the property has been graded; it slopes into this ditch that runs the length of the property…That water is retained as much as possible.” Edward explained how his operation was converted from a farm to a nursery. Edward said,

It was turned into a nursery in the '90s. They used the latest technology at the time to make it as efficient and environmentally friendly as possible… irrigation channels were developed to direct that runoff back towards the pond.

Adoption of water conservation and treatment technologies was not always compatible with growers’ traditional views of horticulture. Some growers felt that technology cannot replace the human aspect of horticulture and were less inclined to adopt new technologies. These views were consistent with Rogers’ (2003) generalization that compatibility with beliefs and values may influence adoption of a new technology. Those who began working in crop production in previous decades took pride in the manual labor that went along with their industry. Phil said, “I didn’t grow up in a technology world, so I don’t look at things that way… I try to tell [younger growers] that is this is not a technology business.” Phil went on to say “You could use technology, but this is a manual business.” When automated irrigation systems were mentioned Lance proclaimed that he has, “never been a firm believer” of that type of system. Lance explained several factors that shaped his opinion regarding certain technologies such as his father would always say, “The best [horticulture techniques] in the world is the master's [owner’s] footsteps, wandering around and making those decisions.” Tyler shared his opinion by saying, “technology is really helpful, but horticulture is so manual.”

However, some growers expressed an opposing viewpoint. These growers felt the recycling and re-use process was so important they even redesigned their nursery property to make their operations more compatible so they could save water. This implies there are innovators who are willing to break from tradition and try something new if their actions will protect the environment and ensure a future water supply.
Complexity
Participants thought that many of the water conservation and treatment technologies were too technologically advanced or tedious for their operation. Steve, Rhonda, Robert, and Tyler have all postponed implementing technologies due to their comfort level. In regards to drip tape, Steve stated “Consistency’s an issue…We have not felt comfortable about that style of production to make it happen.” Robert believed that a soil moisture system was too technical and not user-friendly for the average grower. Robert did not hesitate to say, “A lot of the guys that work for us did not feel comfortable working with this system. It needs to be easy to use for just a general person.”

Soil moisture sensors and their real-time data that could be used to manage irrigation applications (water conservation) were perceived to be very complex systems by the growers. The main goal of the sensors was to alert growers when water is needed. Rhonda explained, …a sensor, or something like that actually takes empirical evidence and decides whether it needs water versus a feel or a grower’s style of watering. We’re working towards going that way. We just need to get comfortable with the equipment. We have it here and we’re working with it. It’s just it’s a big program, it’s a big system, there’s a lot of variables, so it’s not something that you can easily switch over to. There’s a lot of details we need to get right in order to be comfortable with it being effective.

Tyler expressed his opinion about technical software and programs developed to enhance conservation efforts in horticulture when he stated, “Some of the stuff gets so technical and that’s what the concern is… It’s so technical, you got to have an IT person that’s babysitting that project.”

Trialability
The trialability of an innovation contributed to the rate of adoption of a water conservation and treatment technology. Herbert explained that his operation constantly tests sprinkler systems to determine their effectiveness before implementing them in his operation. Herbert said, “we have the overhead spinners in our shade houses. We actually trialed those, because of the more uniform distribution and the lower flow rate, [which] was a better way to water.” Robert recalled conducting research on the Internet in an attempt to find effective watering technology. Robert stated, “I remember chatting with somebody online about this technology, a local irrigation store got me some samples, I felt comfortable, I tried it for a while, I turned one house into that overhead irrigation [system].”

Participants who had the opportunity to work with scientists to test water conservation and treatment technologies shared their thoughts about innovations that were tested at their operation. Jason described how innovations are trialed at his operation by saying, “We work with the scientific community [testing] water irrigation technology, and we do a lot of research here on the nursery. Frankly, most of our information has come from research here on the nursery [with scientists].” When specifically asked about filter socks as a treatment technology Joseph said, “…they are potentially effective.” He explained that his operation trialed filter socks over a period of a summer with researchers from a university. The short-term experience with the bio socks shaped his decision to defer adoption of the innovation. Joseph went on to say that in order for him to implement bio socks at his operation he would, “have to see
improvement in the areas that [he] earlier defined as a deficiency.”

In an optimistic tone Calvin stated, “We’re currently working on developing a sensor-based system. We did quite a bit of testing earlier this year…We got a couple little bugs to still work out on it, but we are pretty confident that it’s going to work.” By trying the sensor based system Calvin was able to form a favorable opinion about the innovation. In fact, Calvin’s operation, “hoped to have [a sensor based system] in place before next spring…until we’re able to roll out the more scientific sensor based technology, we know we’re going to be wasting water.”

Lance, who had an opportunity to try sensors through a university study stated, “I'm not totally sold on the sensor technology.” When asked to elaborate more Lance explained from his limited time with sensor technology, “… the sensors have shown us how efficient we are with our water… we can't just say, okay, you're going to water so many hours every day. We have to monitor our crops and water as needed.”

Observability

Observability of water conservation and treatment technologies also contributed to growers’ decision to adopt or not adopt an innovation. Phil acknowledged that he has observed water-related technologies at other growers’ operations and eventually implemented them. Phil assertively stated, “…you visit nurseries, you see things, you steal ideas, back and forth. I don’t know if that’s innovative or what it is…When I go, I’m looking at their irrigation system.” Phil went on to say, “We’ll have people that come, and that’s all they want to see is our pump houses.” Jason said, “We look at research that’s been done in other places and see how it can apply to our nursery. We also sometimes invite researchers to come and do research on our property.”

Trade shows were a common place for growers to see ideas at work. Ben shared that his operation uses pulse drip irrigation to conserve water, which is a scalable irrigation method designed to save water. When asked if there was anything that he observed at a trade show and implemented in his operation Ben said, “Yeah, matter of fact, that’s the main way we learned about the pulse watering… It was at trade shows.” Ben explained that this was how he learned, “[an] advantage to that pulse type watering is you’re not putting as much water on [crops]. You’re not leaching as many of your nutrients out of it, and so because of that, you’re conserving nutrients.”

Conclusions, Implications, and Recommendations

There is great diversity in perceptions related to water saving technologies across the nursery and greenhouse industry. Recycling and re-using water was the most common water conservation practices used by the growers interviewed in this study independent of the U.S. regions within which they operated. Participants reported that engaging in water recycling or re-use reduced their use of additional water (e.g. municipal and ground water) and benefited their business economically. This aligns with Jara-Rojas et al. (2012) that found the primary relative advantage growers perceived of new technology adoption was a larger profit margin.

In addition to financial benefits, the majority of the participants believed water conservation and treatment technologies were advantageous from an environmental perspective when compared to traditional irrigation techniques. They asserted that pulse drip irrigation, ebb and flood systems, and soil moisture sensors were innovative methods of irrigation that superseded previous methods indicating the relative
advantage of adoption of water saving technologies are broadly accepted among growers in the U.S. Despite potential benefits it was found financial cost was a primary barrier to adoption and that beyond water re-use and recycling new technologies were not always seen as economically advantageous. However, many of the participants affirmed that while the cost of implementing water saving systems were high, the benefits of increased performance that these technologies offered were worth the financial investment. When educating growers about water conservation, extension professionals should emphasize the importance of water conservation as well as the relative financial advantage of adopting new technologies despite their upfront costs.

Participants were also found to be resistant to new technologies because of their perceived complexity that it did not fit within their traditional parameters. Participants expressed that many technologies developed to assist in water savings were not user-friendly for the average grower or irrigation specialist. Hall, Dennis, Lopez & Marshall (2009) determined that for floriculture growers, ease of implementation was the most influential factor influencing adoption of sustainable practices. Their findings, along with those in this study, suggest that as new technologies emerge, simplicity needs to be emphasized. Extension professionals should consider how to simplify a new process prior to introduction. A less complex water conservation technology that is efficient and effective could build confidence and comfort in using additional technical innovations. The development of short videos and/or infographics, made accessible online, showing step-by-step instructions on how to integrate and operate new technologies while emphasizing their advantages may also help alleviate concerns regarding the complexity of “new” technologies.

Several participants also reported testing an innovation for a short period of time without a required commitment gave them an opportunity to form an opinion about a new technology and in several cases allowed them to overcome their preconceived notions about complexity. However, findings from this study also confirmed those of Chapman et al. (2010). Several participants suggested trialability of water conservation and treatment technologies had both a positive and negative effect. The growers who had tried new technologies before adopting felt the experience gave them the opportunity to form their own opinions. However, in some cases, trying the technology resulted in their disliking the product and returning to prior methods. Based on this feedback, extension professionals should consider the technology when deciding whether or not they want to offer an option to try it out prior to full adoption. In some cases, trying a new technology in a small setting may make it seem inappropriate and result in non-adoption, whereas had a grower adopted the technology fully, they would have been able to take full advantage and seen the large-scale benefits of the technology.

On the other hand, participants that were able to observe new technologies being used successfully by other facilities, rather than trying it personally, had an improved perception of adoption. This finding aligns with Chappell et al. (2013) when they found growers that observed technology were not only more likely to adopt the technology they were observing but also expand their adoption to other technologies being discussed at the time of observation. Based on this finding, extension professionals should consider attending trade shows and commodity group meetings or hosting field days with demonstrations of new
technologies to provide a platform for growers to observe new technology use, interact with their various settings and functions, and learn how the technology could be implemented at their own operations.

Future research should be conducted to further examine the decision-making process growers go through when considering the adoption of new water conservation and treatment technologies. A survey with a random sample of growers would provide generalizable results that could be used to further inform the practice of extension with this important audience. In addition, interviews, focus groups or surveys covering the adoption of water conservation and treatment technologies should be conducted in other countries that have an urgent need for water conservation to determine if need, cultural differences, or industry norms impact rate of adoption. The findings could then be compared across nations to develop extension programming that would be transferable and create global impact.

Research should also be conducted on the suggested extension programming. For example, once videos are developed and shared online to reduce perceived complexity, scientists should examine if they have the desired effect and increase the rate of adoption. The same could be done to determine if offering opportunities that engage growers in observing technologies enhances their rate of adoption. Finally, since the financial advantages of adoption were found to be the largest influence in this study and the previous literature on the topic, research should be conducted to determine if communication messages and extension programming focused on the financial gain growers would obtain through adoption of new technologies had a dramatic change on adoption. Continuing this research line would add to the literature base with this important audience (nursery and greenhouse growers) that uses an excessive amount of water, but would also assist in informing the theoretical aspects of technology diffusion in the U.S. and around the world.

References


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