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Leveraging Shared Interests to Advance Sustainable Food Safety Systems in Cambodia

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Abstract

In many Low-Medium Income Countries (LMIC), smallholder farmer access to consumer-driven markets is limited by lack of knowledge, capital, appropriate technology and technical training. While technical innovations and new techniques can improve the quality, quantity and safety of agricultural products for the market, adoption of new technologies and practices by smallholder farmers is often hindered by additional social and logistical constraints. To address the wide range of problems experienced by smallholder farmers seeking a higher standard of living, both natural

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science and social science solutions are required. This pilot study describes a mechanism for overcoming multiple constraints smallholder farmers face when attempting to change their agricultural practices. Community-driven savings programs were organized around the shared interests of individuals involved in various aspects of the agricultural supply chain in six villages in Cambodia. These Shared Interest Savings Groups (SISGs) were initially designed to help members learn to (a) amass lump sums of capital for investments in agriculture, and once operational also served as an organizing platform to (b) collectively identify problems and test solutions, and (c) provide funding for early scaling of appropriate agricultural technologies. This case study proposes an innovative model for effectively mitigating multiple constraints that typically hinder LMIC agricultural advancements. The participatory, social learning SISG model is therefore a promising soft technology that warrants further testing at a larger scale to validate these findings.

Keywords: participatory research; social learning; shared interest savings group; smallholder farmers; value chain; technology adaptation

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1.0 Introduction

In 2007, World Bank reported "the vast majority of farmers in developing countries are smallholders, and an estimated 85% of them are farming less than two hectares" (2007). Yet in these Low-Medium Income Countries (LMIC), smallholder farmer access to consumer-driven markets is often limited by lack of knowledge, capital, appropriate technology and technical training. Recognizing the challenges of smallholder farmers, in 2012 during the UN General Assembly, the United States (U.S.) committed $1 billion in "local level" aid to secure the world's access to healthy food (Clinton, 2012). In 2013, the U.S. further committed to improve livelihoods in LMIC over the next two decades by eradicating extreme poverty (Obama, 2013). This commitment launched the U.S. Agency for International Development (USAID) Feed the Future initiative (FtF) which addresses global hunger and food insecurity by focusing agricultural funding on poor and food insecure countries (U.S. Agency for International Development Feed the Future Initiative, n.d.). The importance of FtF in improving the agriculture sector in developing countries has been described in the Advisory Committee on Voluntary Foreign Aid (ACVFA) recommendations:

> [In] several of the countries where FtF agencies operate, the political support for civil society is constrained—this very constraint threatens sustainable gains in long-term food security. FtF, with its focus on smallholder agriculture and equitable economic growth, can and should be a vector for increased voice and representation of civil society—making this a cornerstone of efforts to promote an enabling policy environment for agriculture (Beckman & McNamer, 2013).

1.1 Characteristics of Smallholder Farmers in Low-Medium Income Countries

Smallholder farming households include 2.5 billion people worldwide (Conway, 2012; Hazell, Poulton, Wiggins, & Dorward, 2007; International Fund for Agricultural Development [IFAD], 2011; World Bank, 2007). On the approximately 500 million smallholder farms that are home to these individuals, agriculture can be segmented into three distinct groups based on farming households' engagement with market systems and demand for agriculture related financing (Peck, Anderson, & Anderson, 2013). Distinctions of smallholder farming households are useful as indicators that highlight household agricultural activities independent of their relative importance to total household income. As agricultural improvements and economic growth occur, changes in access to agricultural technologies, financial services and markets can be measurements of farmers' improved positions in the value chain. Agricultural value chains include all the linked activities and actors involved in the food supply chain (Donovan, Franzel, Cunha, Gyau, & Mithöfer, 2015) and extends from input provision, production through harvesting, processing of raw products, and delivery to marketers who sell food to consumers. Dynamic elements within value chains can synergize and result in economic growth within agricultural communities when multiple actors gain access to technologies and improve farm production and distribution of agricultural products to reach consumers.

There is an evident continuum along which smallholder farming can be evaluated from a subsistence level to the building of an effective value chain that allows farming enterprises to gain a competitive toehold in the market (Peck et al., 2013). At the subsistence level are the noncommercial farmers. They have no land or less than one hectare and often produce staple crops that are mostly consumed by the household. These farmers have very little engagement with markets and tend not to sell food. They have limited access to improved agricultural technologies and very restricted access to financial services. Noncommercial, subsistence farming comprises approximately 60% of the estimated 500 million smallholder farms worldwide.

Commercial farmers comprise the second and third segments of the smallholders and can be divided into two distinct categories: those who function in informal or 'loose' value chains and those who have stronger tighter connections with other value chain actors (Peck et al., 2013). Commercial smallholders with loose value chain connections represent approximately 33% of all smallholder farms. Although farmers in this group sell some of the food they grow at informal local or regional markets, they are still considered very poor. It is notable that this second group of smallholder farmers includes many women. With one to two hectares of land, these farmers produce mostly staple crops with some production of higher-value crops such as horticultural products—fruits and vegetables. They usually have enough commercial activity from surplus crops that they can access informal local financial services, which potentially offers capital and opportunity to diversify assets and sources of income. The third segment of smallholder farmers are also commercial growers but have more structured participation in value chains. This group generally has more than two hectares of land and represents approximately 7% of the world's smallholders. Generally, fewer women are in this group of smallholders which is considered less poor and more resilient than the other two segments. A sizeable portion of this group's agricultural income may be from higher-value crops sold in regional or export markets through contract farming. This group also tends to use comparably advanced technology and has greater access to formal credit, which is often provided by the buyers with whom they work. Segmenting smallholder farmers into (a) noncommercial smallholders, (b) commercial smallholders with loose value chain connections, and (c) commercial smallholders with tight value chain connections, highlights the different needs each group have when taking production to the next level.

1.2 Opportunities and Challenges to Agricultural Development

Many challenges can be addressed by modernizing smallholder farming. Major priorities include developing economic opportunities that improve livelihoods for smallholder farmers in all segments, producing safe food supplies for consumers, and reducing national and household food insecurity. Technical innovations and improved techniques can improve the quality, quantity and safety of agricultural products for the market and increase the value of agricultural products and income of actors throughout the value chain (Birch et al., 2015; HLPE, 2013; Bowman, 2012).

Adoption of new technologies and practices by smallholder farmers is often hindered by a variety of constraints (Diederen, Van Meijl, Wolters, & Bijak, 2003; Fitzgerald & Sovannarith, 2007). These constraints include physical, logistical and social factors (World Health Organization, 2015). Physical constraints include inadequate facilities and infrastructure such as absence or shortage of safe water, electricity or storage facilities. Logistical constraints include many factors that affect food production, transportation, processing and marketing systems. Logistical challenges also include poor post-harvest handling, processing, and storage of food. In LMIC, the logistics required for these processes are highly fragmented which often results in many food handlers and inefficiencies that compromise food safety and quality.

In addition to physical and logistical constraints, smallholder farmers face socially-based challenges (Cattell, 2001; Gregson, Terceira, Mushati, Nyamukapa, & Campbell, 2004; Grootaert & Van Bastelaer, 2001, 2002; Harriss, 2002). Many issues affect people's ability to incorporate change within existing social systems. Traditional farming practices and agricultural value chains have been established over decades or even centuries. Proposed changes in such established systems can often conflict with elements of tradition that make incorporating change particularly challenging. Large adjustments made too quickly or without appropriate incentives within existing social structures can result in the inability of people to manage change, even in situations when the change is positive.

To overcome these constraints, new technologies or practices intended to help improve smallholder farming must fit within the established physical, logistical, social, financial and political environment. Care must be taken to evaluate how new ideas fit or conflict with rooted elements of tradition. To facilitate lasting change for smallholder farmers, it is essential that new technologies and practices blend with knowledge of and consideration for the existing systems in which they are intended to function. Only when new ideas function well in each context will they be accepted by local actors. Recognizing this, the World Health Organization advocates for approaches that learn from existing systems to identify how change can be incorporated in manageable increments. Overall, questions about how new practices can be designed to incorporate the knowledge base of local experience, equip locals to manage changes, and incentivize expansion within local social structures need to be addressed to sustain change (World Health Organization, 2015).

Given these recommendations, new system-based approaches are required to develop transdisciplinary solutions to the problems faced by smallholder farmer communities (Collins, 2017). Improvements in agricultural productivity and increased economic stability for smallholders requires both natural science and social science solutions. Natural sciences can offer hard technological solutions—tangible items that can be introduced and adapted to improve agricultural production and food distribution. For example, hard technologies include: (a) new seed varieties, (b) fertilizers, (c) pest management techniques, (d) water distribution systems, (e) postharvest handling–packaging centers, and (d) cold storage–distribution systems (Kitinoja & Barrett, 2015; Kramol, Villano, Fleming, & Kristiansen, 2012; Toivonen, Mitcham, & Terry, 2014). Adoption of hard technologies are more easily integrated into existing value chains when accompanied by complementary soft technological innovations—social science solutions that build interpersonal connections, knowledge, and local leadership (Cattell, 2001; Häuberer, 2014; Ibargüen-Tinley, 2014; Ksoll, Lilleor, Lonborg, & Rasmussen, 2012; Musinguzi, 2016). This social side of technological adoption requires platforms for information dissemination in ways that develop local ownership and community support systems to facilitate incorporation of hard technologies into existing value chain structures. However, examples of transdisciplinary integration that supports development of both hard technologies and the complementary soft technologies required to use them are lacking.

This case study describes a set of economic, social and humanistic innovations offering the potential to facilitate the adoption and adaption of new hard technologies by end-users. This systems approach focuses on the role of community savings groups to build financial capacity for introducing and scaling technologies. In addition, the social structures within groups encourage information exchange and risk mitigation that fosters mutual learning, testing, assessing, refining and adapting new agricultural technologies once they are adopted. The results described here offer a new perspective into how smallholder farming communities can be engaged as partners to overcome multiple physical, logistical and social constraints frequently cited as barriers to adoption of new technologies.

2.0 Context

2.1 Savings Group Formation for this Study

This pilot study, Rural Investments in Agricultural Technologies, was conducted in agricultural communities in Cambodia (Miller et al., 2017). Firstly, a major advantage of working in Cambodia was that the research team was already engaged with smallholder farmers outside the capital city of Phnom Penh through an existing Feed the Future project with university counterparts at the Royal University of Agriculture (Trexler, Miller, & Young, 2014). The Horticulture Action Research and Education Network (HARE–Network) project was funded by the USAID Feed the Future Innovation Lab for Collaborative Research on Horticulture. The Network's overarching goal was to conduct participatory-based safe vegetable research and development that integrated both natural and social sciences. Safe vegetables have been defined regionally as those produced following international standards related to proper pesticide and fertilizer use, clean water quality, low microbiological pathogen counts, and low levels of toxic heavy metals (Duong, n.d). The aim was to address the greatest concerns of and develop practical solutions for smallholder farmers in ways that improved the safety and quality of vegetables.

Secondly, a major advantage for pursuing this new idea in Cambodia was that savings groups were already familiar to the area. At the time, a well-established non-governmental organization, Oxfam Cambodia, had initiated over 360 savings groups since they were first introduced in 2005 (Emerging Markets Consulting, 2012). Lastly, Cambodia was a prime location for examining the social side of innovation: how to develop platforms for information dissemination and social support systems that are required for incorporating hard technologies into existing value chains.

In Cambodia, a particularly low level of trust exists between value chain actors and this is a significant barrier to establishing strong links within the value chain (Cattell, 2001; Colletta & Cullen, 2000a, 2000b, 2002; Frings, 1994; Grootaert & Van Bastelaer, 2001, 2002; Häuberer, 2014; Kula, Turner, & Sar, 2015; Ovesen, Trankell, & Öjendal, 1996; Tokuda, Fujii, & Inoguchi, 2010; Whitley & McKenzie, 2005). Cambodia's dearth of social capital affects the ability of value chain partners to develop and sustain new working relationships and limits the ability of smallholder farmers to make progress through the generalized categories that reflect economic growth for smallholders. This social context offered an environment where the effects on community social structures could be easily observed.

Among established savings group models, this pilot study adopted the 'Savings for Change' methodology, which was developed and refined by Freedom from Hunger (an American non-governmental organization [NGO]), tested in Mali by Oxfam America (Ashe, 2009; Freedom from Hunger, 2014), and is currently being used in more than 90 countries to address poverty and serve as a platform for social change (Ashe, 2014; Benda, 2013; Delavallade, Dizon, Hill, & Petraud, 2015; Edwards, 2010; Fitzgerald & Sovannarith, 2007; Freedom from Hunger, 2014; Gregson et al., 2004; Ibargüen-Tinley, 2014; Karlan et al., 2012; Kim et al., 2007; Ksoll, Lilleor, Lonborg, & Rasmussen., 2012; Musinguzi, 2016; Saha, 2014). 'Savings for Change' not only focuses on savings but also uses the weekly member meetings to target modules of education and training around such topics as financial literacy and preventative health. The research team's idea extended beyond the original 'Savings for Change' model and introduced the idea of Shared Interest Savings Groups (SISGs). The idea that differentiated SISGs from other savings groups was that all members would share a common interest. SISGs were intended to consist of farmers and a mix of farm laborers, input suppliers, transporters, food processors, machinery repairers, marketers and other members of the community who possessed a strong self-interest in the well-being of farm families. Individuals from farm families who support agriculture in other ways would also be included, for example, community members who sustain the efforts of farmers through off-farm employment or act as merchants and service providers who support agricultural operations (i.e. equipment suppliers, mechanics or providers of capital). The idea of SISGs was that organizing people around the common interests of farmers would develop a platform for collective decisions around age-old smallholder concerns of seasonality, income smoothing, input purchasing, pest management, marketing, scaling, risk mitigation and coping with change.

Six villages in Kandal Province were identified as areas ripe for the study. Individuals involved in various aspects of agriculture were recruited to participate in SISGs. Altogether, members of SISGs represented a diverse group of individuals within communities who shared an interest in maximizing the production of high quality, healthy agricultural products and sought to bring the greatest return on investment to farmers and other value chain actors. While a considerable amount of focus was placed on smallholder farmers, the concept of SISGs was that group members with diverse interests in agriculture would be empowered to act as agents of change that supported farming and the ability of the community to thrive.

2.2 What is a Savings Group?

Savings groups following the 'Savings for Change' model are autonomous, self-governing mechanisms for saving money among a small group of trusted individuals. Community-driven savings programs usually involve between 15–25 members and function independently of any micro-finance institution. Membership is self-selecting and members who choose to be part of a savings group decide together the details of how the group will function. Each group owns and manages the process of meeting weekly to record and deposit member savings and take or repay loans (see *Figure 1*: Treasurer of SISG recording members' weekly savings and loan activity at group meetingFigure 1). At weekly meetings, members can borrow money from the group at a low interest rate agreed upon by the participants, usually 2% per 28 days for personal and business investments. Groups operate and are governed by an elected body agreed upon by its members. Every 12–24 months, depending on each group's bylaws, the savings and loan cycle is closed and the funds are distributed back to its members, including interest earned as a percentage of each individuals' contributions. The group is then open to new membership and additional community members who wish to participate in the next savings cycle can join. Membership in a single group is most often limited to 25 participants. In cases where more than 25 community members wish to participate, members divide into two groups at the beginning of a cycle. Existing leaders train experienced members in the first group to become new leaders in the spin off group. In this way, savings groups are self-sustaining and self-replicating.

Figure 1: Treasurer of SISG recording members' weekly savings and loan activity at group meeting.

Source: Project photo.

Members own and manage all saving group activities and thereby learn, through experience, to build incipient civil society structures (Rasmussen, 2012). The highly participatory nature of weekly savings and loan activities encourages collaboration and also builds basic financial tools that are essential for managing group savings and making financial decisions. The lessons learned within the group are particularly impactful for women in LMIC who generally have little opportunity to develop financial management and leadership skills. Savings groups are also particularly attractive to women as a means to avoid social isolation, build collaborative structures within communities, and protect their small savings. Given savings groups' high level of participatory decision-making, the SISG model was designed to serve as a vehicle for collective action to address agricultural problems. In this case study, the new idea was that savings groups were an appropriate soft technology to develop the social structures and financial systems required to identify and overcome constraints to support the adoption of hard technologies by smallholder farmers aimed at improving productivity and food safety.

2.3 Methodology for Identifying Participants and Establishing SISGs

Smallholder farming households that produced relatively significant amounts of horticulture products and other community members who played roles in the horticulture sector were introduced to the idea of savings groups. General information about the Savings for Change model was given and initial discussions centered around six key elements of successful savings groups (a) all members in a group must know and trust each other, (b) comprehensive training and follow-up over the course of one year would be provided by an experienced savings group facilitator, (c) decision-making on rules and regulations would be made with consent of the whole group, (d) the election processes for selecting board members would be transparent, (e) no external incentives or subsidies would be given, and (f) all materials required for managing the group would be purchased by the group.

Subsequently, a promotion meeting was organized to give more details about the benefits and responsibilities of membership in a savings group. Over the following six months, community members who chose to participate organized themselves into 12 groups. Each group agreed on a day and time when members would meet weekly. Over the subsequent seven weeks, each group was comprehensively trained to manage their own savings and loans as well as administer the associated record keeping. Group training sessions facilitated election of board members and establishment bylaws through consensus of all members. Bylaws included important details such as the minimum and maximum amount of savings each group member could contribute each week, the procedure for taking a loan, the interest rate and loan repayment guidelines, the term of the savings cycle (usually one or two years), and guidelines about how redistribution of funds to all the members would occur at the end of the cycle. Some groups additionally elected to set aside a portion of the groups' total savings for a social fund designated for things deemed important to the community. Examples included community development projects or emergency funds to cover unexpected health care costs incurred by members. Groups also purchased a lock box to secure the savings and an account book to record financial activities. After these foundations were in place, members were trained to manage the weekly processes of taking in and recording savings as well as distributing and repaying loans.

After the group training sessions, the groups held weekly meetings on their own. Groups were supported as group leaders learned to effectively conduct weekly meetings as well as manage conflict and uncertainty that arose among group members as they gained confidence in the recordkeeping process. As group dynamics stabilized, a 'Savings for Change' facilitator followed up approximately one time per month for the next year to help check the recordkeeping, answer questions, conduct follow-up trainings as necessary and collect research data. Once a group had functioned for a minimum of six months and the weekly savings and loan meetings were streamlined, trainings on horticultural topics were introduced that supported safe food value chain development, modernizing technologies and best practices to improve productivity while reducing chemical and microbial food safety threats. The topics included new varietals, seed collection, soil tilling, Food and Agriculture Organization of the United Nations approved pest management techniques, mixed cropping practices, composting, drip irrigation, post-harvest processing.

3.0 Methodology

3.1 Case Study Design

This illustrative case study describes a three-year period when SISGs and agricultural technologies were introduced in a rural community by Cambodia's Royal University of Agriculture and the University of California, Davis. Yin (2008) has suggested illustrative case studies are designed to help bridge the gap in the understanding of a topic between the researchers and the target audience. In this case study, we focus on the describing how SISGs served as a point of entry into a community for agricultural research and development activities.

3.2 Population

The population for this study was 149 members of the SISGs in Sa'ang district and 11 vegetable marketers from Phnom Penh Cambodia. In the 12 SISGs, 84.6% of the members were female and 77% identified as farmers, while the remaining 23% were from farming families.

3.3 Sources of Data

Data were collected in various ways using both social science and bio-physical science methods. Social science data were collected via project artifacts such as SISG meeting notes and financial records as well as historical records of the Rural Investments in Agricultural Technologies and the Horticulture Action Research and Education Network (HARE–Network) projects, including, agendas, emails, semi-annual reports, site visits reports and project meeting notes. In addition, focus groups and key informant interviews were conducted with both SISG members and marketers. Focus groups interviews followed standard procedures as outlined by Krueger and Casey (2015), while key informant interviews were designed based on guidelines for qualitative research (Lincoln & Guba, 1985; Patton, 1990) and provided a deeper look into the perceptions of the project activities. Bio-physical data were collected through Nethouse[1] field trials held on lead farmers' land. The

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[1] Mesh netting designed into a house-like structure to protect crops from insect pests.

farmer field trials provided yield and cost data that was later used in a cost-benefit analysis which was shared with SISG members.

3.4 Data Analysis

Data collected through social science methods were analyzed in various ways. Initially, demographic and financial data from the 12 SISGs were analyzed for sums, averages and performance ratios using the SAVIX reporting system which provides transparent and standardized data on community-managed microfinance (Village Savings and Loan (VSL) Associates, n.d.). The SAVIX system has been used extensively for monitoring and evaluation of village-level saving schemes in developing countries. Historical project artifacts were reviewed and holistically analyzed to provide a clear description of project activities carried out within the three-year time frame. Focus group data were analyzed using procedures to identify patterns and trends among the groups' responses (Krueger & Casey, 2015). Field note summaries from key informant interviews were analyzed through the constant comparative method (Denzin & Lincoln, 2011).

Bio-physical data from Nethouse field trials were collected for the express purpose of understanding the effect of using a specific horticulture technology on revenues and costs of production, not for establishing statistically significant scientific results. Production yields and costs per meter from both the treatment and control groups were compared. These data were examined using a basic cost–benefit analysis.

The UC Davis Office of Research has determined that the collection of information and data that occurs during the implementation of a project does not fall under the definition of research as defined by either the Department of Health and Human Services or the Food and Drug Administration and therefore is considered exempt from Institutional Review Board approval.

4.0 Findings

In this section, salient activities and outcomes from the SISGs and hard technology introduction are highlighted to provide a clear timetable for community development activities. We first introduce the characteristics of the SISGs that were formed in the targeted villages. Next, we describe the collectively identified hard technology that became the focus of community-based research as well as the benefits this technology promised to provide farmers engaged in horticulture. After this, we look at the SISGs' financial outcomes and describe the potential for supporting technological adoption and adaption through lending. The findings section concludes with details about SISG loans for new technologies and particulars about how lead commercial farmers planned to scale-up their use and enter into new marketing arrangements.

4.1 Characteristics of SISGs

Within the 12 established SISGs, 149 members were comprehensively trained using the 'Savings for Change' model. The number of members in each savings group ranged from 10 to 19 and averaged 12 members (see Figure 1). Membership consisted largely of women and the number of women participants in each group ranged from seven to 16 with an average number of women per group of 10. Male participants in each group ranged from zero to five and averaged two. Women constituted 85% of the total number of members. Among the 12 savings groups, 43 of the 48 leadership positions were held by women. Within each group, the number of farmers ranged from six to 17 and averaged 10 (see Figure 2). Farmers made up an average of 77% of the total participants and the remaining 23% were members of farming households who supported farming through a variety of activities (see Figure 3).

Figure 2: Group composition by gender of 12 Shared Interest Savings Groups in Sa’ang District.

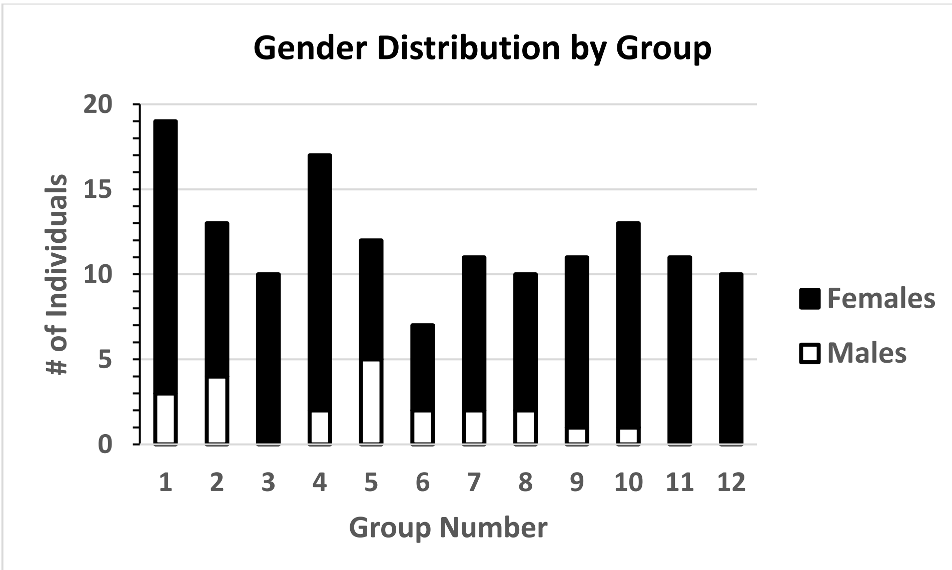
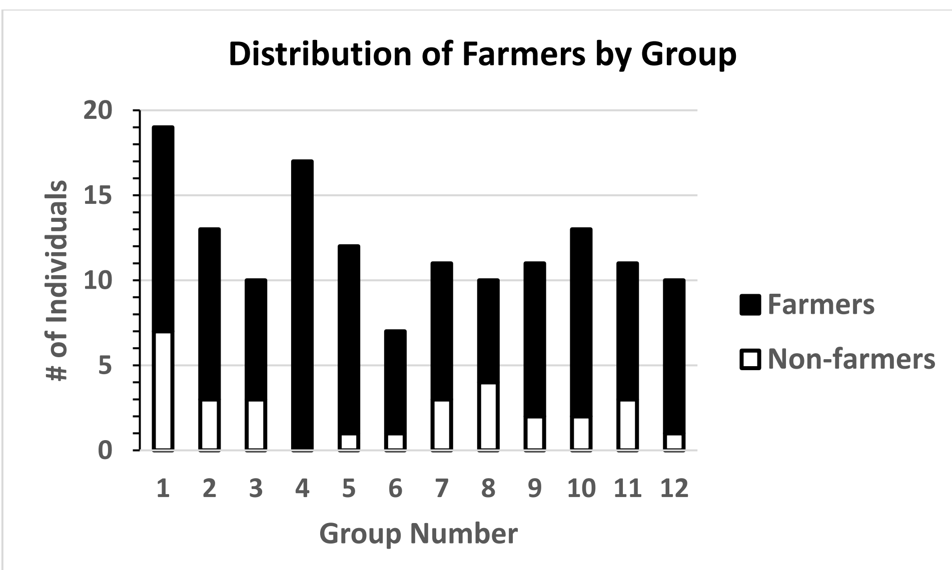


Figure 3: Group composition by profession of 12 Shared Interest Savings Groups in Sa'ang District.



4.2 SISG Members Amassed Lump Sums of Capital that Were Used for Agricultural Loans

After SISGs had been functioning for a period of six months, key economic indicators were collected (see Table 1). The cumulative value of savings for all twelve SISGs was $9,426.38. The amount saved in each individual group ranged from $280.38 to $1,761.25 and averaged $785.53 per group. At that time there were a total of 102 outstanding loans valued at $7,747.50. Of the total number of members in all the groups, 68% had outstanding loans that averaged $75.96 per loan. Of these, 86 were used to invest a total of $7,442.50 in horticulture farming. The additional $305.00 in outstanding loans were for other household expenses related to healthcare, education, animal raising, fisheries or other small business activities. At this point in time, the average amount of cash accumulated in each group's cash box was $173.37 which was available to be lent out to members. Additionally, 11 of the 12 groups set aside a social fund for various purposes including road improvements and community festivals. The total accumulated in all social funds was $271.98.

Table 1: *Key Economic Indicators of the Savings Portfolio of 12 SISGs After Operating for Six Months*

	Total	**Average per group**
Cumulative Value of Savings	$9,426.38	$785.53
Number of Outstanding Loans	102	9
Value of Outstanding Loans	$7,747.50	$645.63
Members with Outstanding Loans	68%	
Number of Horticulture Loans Outstanding	86	7
Value of Horticulture Loans	$7,442.50	$620.21
Accumulated Cash in Box	$2,080.45	$173.37
Value of Social Fund	$271.98	$24.73

4.3 SISG Members and Other Value Chain Actors Collectively Identified Opportunity for a Hard Technology to Address Locally Significant Agricultural Problems

Once groups had functioned for a minimum of six months and the weekly savings and loan meetings were streamlined, trainings on other topics were introduced. To initially acquaint SISG members to various horticulture technologies, they were invited to participate in Cambodia's first Technology and Market Fair which was organized by the project team and the HARE-Network university counterparts at the Royal University of Agriculture. Demonstration sites were established at the Royal University of Agriculture to highlight the potential usefulness of hard technologies including low net tunnels, soil solar disinfection, cool storage using a CoolBot walk-in cooler controller, drip irrigation, solar drying, drying beads, and composting. SISG members traveled to the university campus to learn about these technologies and how to evaluate their potential to bridge gaps in the horticultural value chain. In total, 39 SISG members and 11 wholesalers and retailers from Phnom Penh-based retail outlets participated.

Subsequently, focus group discussions and a series of participatory workshops were organized through savings group meetings for various stakeholders to evaluate their roles within the safe food value chain and examine the potential for collaboration. Retail outlets and farmers determined the primary constraints to effective linkages between them resulted from the low-quality and hygiene of locally grown produce and overuse of pesticides. Participant stakeholders were further guided through the process of evaluating each technology demonstrated at the Technology and Market Fair so they could determine which were the most relevant to overcome the barriers the group identified. Low net tunnels were selected by the group as a technology with potential to improve product quality and reduce pesticide use by forming a physical barrier to protect crops from insect damage (see Figure 4). A group of participants agreed to use this technology for further experimentation both at the university and on farmers' plots within the villages. Overall, the community-led participatory research redesigned the low net tunnels into a taller structure high enough to walk inside (see Figure 5). This structure is now commonly referred to in Cambodia as a Nethouse.

Figure 4: Demonstration plot showing the use of low net tunnels at the Royal University of Agriculture.

Source: Project photo.

Figure 5: Participatory research led to the redesign of low net tunnels into a Nethouse structure farmers could enter and walk through.

Source: Project photo.

4.4 Farmers Earning Potential is Higher when Investment in Nethouse Technology is Made Compared to Traditional Cultivation Practices in Open Fields

Initial results from collaborative research and farmer field trials suggested a coordinated business model among farmers and marketers developed around Nethouses could be effective for meeting the goals self-identified by each group during the initial focus group discussions first conducted through savings group meetings. To further investigate this idea, data from the farmer field trials was used to conduct a basic cost–benefit analysis that could be used to present to the larger group of SISG members (see Table 2). Lead farmers agreed that a convenient size for a Nethouse would be larger than the small trial structures. Therefore, calculations were based on a 160 m^2 Nethouse. The total cost to purchase a 160 m^2 Nethouse including all transportation and labor costs is $500. The life expectancy of the UV coated net material from Thailand is five years. Therefore, basic calculations were made to estimate the costs and expenses over five years to determine an estimated net profit. Conservative estimates of yields are based on assumptions from the farmer field trials at 1 kg/m^2.

Farmers can typically grow an estimated nine cycles per year and even more if they use germination tables to shorten crop cycles. To avoid overestimating yields and revenues, these calculations are based on eight crop cycles per year. An exception is given for the first year for crops grown inside a Nethouse. The first two months of production is not included to account for the time farmers need to slowly start production using a cropping calendar since it would prevent the full space inside the Nethouse from being used from the beginning. Therefore, it was estimated in the first year of production inside a 160 m^2 Nethouse would be 1,066 kg—calculated at 1 kg/m^2. Production for the remaining four years was estimated at 1,280 kg annually—1 kg/m^2 x 160 m^2 x 8 cycles/year) for a total of 5,120 kg estimated total production for years 2–5. Production in open fields without a Nethouse was estimated at 1,280 kg/year (1 kg/m^2 x 160 m^2 x 8 cycles/year) for a total of 6,400 kg. The cost of inputs for a 160 m^2 plot of land was estimated for seeds, fertilizer, diesel for the water pump, as well as general supplies and repairs. While these costs vary over the course of a year, calculations were based on lump sum estimates provided by farmers and a lump sum of $10/month was estimated. The cost of pesticides for a 160 m^2 plot of land was estimated at $50/year based on estimates provided by farmers during the field trials. As this was not intended to be an all-inclusive accounting, some costs including labor were not estimated. It is notable, however, that using a cropping calendar and eliminating pesticide usage are less labor intensive than traditional farming techniques. Therefore, the total cost of inputs for five years was estimated at $600 (10 USD/month x 12 months x 5 years) for crops grown inside Nethouses and $850 (50 USD/year x 5 years for pesticides + 600 USD for other inputs) for crops grown in open fields without Nethouses. Gross revenue was calculated for crops grown inside Nethouses assuming a conservative stable market price of 2,000 Riel/kg (0.50 USD/kg), even though this is typically the minimum price for chemical-free leafy vegetables and higher prices can be achieved. Estimated gross revenue for crops grown in open fields without Nethouses came from field trial data and assumed a higher than average market price of 1,000 Riel/kg (0.25 USD/kg). Given these estimates, net profit over the 5-year expected life-span of a 160 m^2 Nethouse was calculated at $1,993, approximately $400/year. For crops grown on 160 m^2 of open field, calculation of conservative estimates over a 5-year period reveal farmers net profit would be $750, approximately $150/year. While most farmers do not track production costs for such cost–benefit analyses, a common joke among farmers is a comparison of agriculture to playing the lottery—‘sometimes you win big, but most of the time you just keep losing your money.’ During focus group discussions, when asked why they continue farming with high uncertainty and sometimes operate at a loss, many farmers responded with the same sentiment articulated by one farmer who said, “if I don’t farm, what else will I do?”

Table 2: *Basic Cost–benefit Analysis, Estimates Calculated From Field Trial Data*

	Inside Nethouse	**Outside Nethouse**
Initial Investment (USD)	$(500.00)	$0.00
Cost of Inputs for 5 Years (USD)	$(600.00)	$(850.00)
Production Year 1 (kg)	1,066	1,280
Revenue Year 1 (USD)	$533.00	$320.00
Production Years 2-5 (kg)	5,120	5,120
Revenue Years 2-5 (USD)	$2,560.00	$1,280.00
Net 5-year Profit	$1,993.00	$750.00

4.5 SISG Members Amassed Lump Sums of Capital that Were Available for Investing in Nethouses

Of the marketers participating in the project, one shop owner wanted to develop a contract purchase agreement with farmers who could grow under Nethouses. At this time, contract farming was not common in Cambodia (Eliste & Zorya, 2015). This shop wished to purchase 100 kg of safe, high quality vegetables per day. Given that preliminary results indicated a coordinated business model among farmers using Nethouses and marketers specializing in safe vegetables was possible, the concept was presented to SISG members. Focus group discussions and farmer field schools that demonstrated Nethouse production and got farmer feedback were conducted. Subsequently, a survey of 26 farmers revealed that 17 were interested to invest in a Nethouse for their farm, five were not interested in investing in this new technology, and four wished to wait to see how the innovation would work in their community.

When savings group had functioned for 12–17 months, key economic indicators were again collected (see Table 3). Eleven of the 12 groups had conducted the annual closing cycle and distributed the savings plus interest back to the members. Members from eight of these groups elected to reinvest most of their distributed funds back into the savings group as seed money to fund larger loans for the next savings cycle. The cumulative value of savings for all twelve SISGs was $31,627.65 and the amount saved in each individual group ranged from $476.25 to $8,084.88, averaging $2,635.64 per group. A total of 131 loans valued at $28,697.50 were outstanding and each loan averaged $284.13. Of these, 101 were used to invest in horticultural farming. At this point in time, the average amount of cash accumulated in each group's cash box was $404.16 which was available to be lent out to members. Of that, 11 of the groups had an average $20.51 set aside in a social fund. Since inception of the savings groups, a total of $577.40 had been saved in social funds and of that, $331.25 had been taken out to be used for road improvements and community festivals. Since the inception of the savings groups, a cumulative total of $60,775.00 in horticulture farming loans were cycled through the SISGs.

Table 3: *Key Economic Indicators of the Savings Portfolio of 12 SISGs*[*]

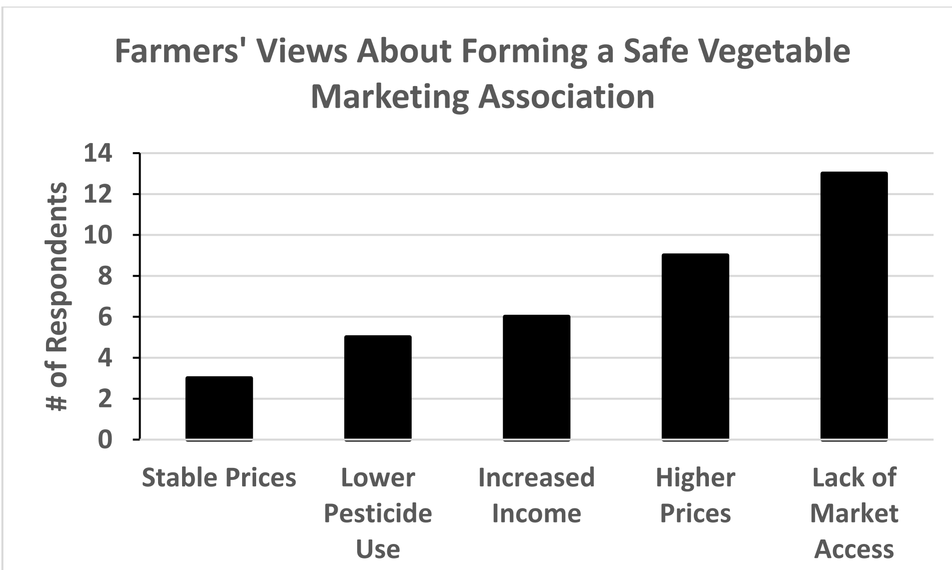
	Total	**Average per group**
Cumulative Value of Savings in Current Cycle (USD)	$31,627.65	$2,635.64
Number of Outstanding Loans	131	11
Value of Outstanding Loans (USD)	$28,697.50	$2,391.46
Members with Outstanding Loans	68%	
Number of Horticulture Loans Outstanding	101	8
Cumulative Value of Horticulture Loans since Inception (USD)	60,775.00	$5,064.58
Cash in Box (USD)	$4,849.95	$404.16
Value of Social Fund (USD)	$246.15	$20.51

*Each group had been operating for 12–16 months.

4.6 Participating Farmers Were Willing to Invest in New Technology, Move Away From Traditional Practices and Adopt Attendant Marketing Avenues

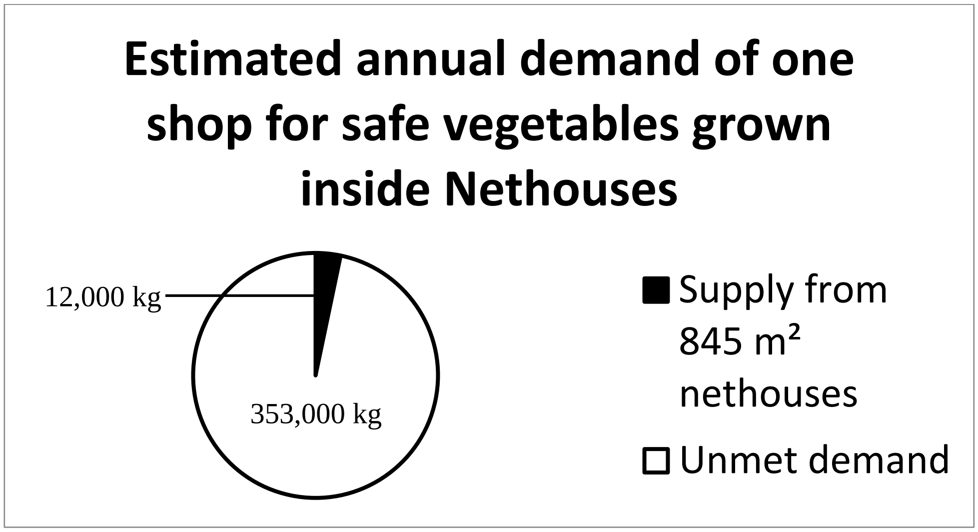
Farmers were asked to participate in one of three focus group discussions. Among the topics discussed with 26 SISG members was the potential for savings group funds to be a source for investment in Nethouses. Among the group, 17 farmers stated they could take a savings group loan over $300, while nine farmers said their group would not give loans higher than $300. Many farmers stated they would also tap other sources to compile enough capital for a large investment. Farmers were also asked what they viewed as advantages and disadvantages to forming a safe vegetable marketing association (see Figure 6). The advantages directly linked to farm economics were cited most often, namely, higher and stable prices, lower use of pesticides and a general increase in income. The most prominent concern for farmers was lack of market access, indicating farmers were cautious about investing in Nethouses if they could not be sure of a long-term purchasing agreement.

Figure 6: Reasons farmers cited when asked what they viewed as advantages and disadvantages to forming a safe vegetable marketing association.



By the project's last follow-up visit to the SISGs by the 'Savings for Change' field facilitator, two farmers who were involved in innovating and testing the Nethouses invested in a total of 845 m^2 of Nethouses and signed 1-year contracts with one small vegetable shop marketing safe vegetables. Additionally, preparations were being made for an additional 480 m^2 of Nethouses to be constructed. As part of the contract, farmers agreed to adapt their traditional cultivation and postharvest practices, synchronize crop rotations and diversify production using good agricultural practices. The average price for 1 kg of safe vegetables in the contracts was 3,400 Riel (0.85 USD), which far surpassed the price used for the cost–benefit analysis. From the 845 m^2 of Nethouses already constructed, the farmers consistently supplied the shop three times per week with 65 kg of a variety of safe vegetables, for a total of 195 kg per week. As the farmers continued to use the cropping calendar and the cultivated area inside the Nethouses increased over the coming month, production rose to 300 kg per week. At this production rate, 845 m^2 had potential to produce 12,000 kg of safe vegetables per year from two farmers, including an adjustment for the lower production expected during the rainy season. The revenue generated by each farmer in one year is estimated at $4,500, far beyond the typical annual rural income in Cambodia of around $1,000 in 2014 (CEIC, n.d.). The marketer reported a shortage of supply for safe vegetables produced under Nethouses (see Figure 7). Given that farmers using Nethouses were producing an estimated 12,000 kg, the annual shortage in supply was 353,000 kg. To meet this demand, approximately 3,250 m^2 of additional land under Nethouses would be required.

Figure 7: One small shop's estimated annual demand for safe vegetables.



5.0 Discussion and Recommendations for Next Steps

The initial USAID HARE-Net project's overarching goal was to conduct participatory research and development that integrated both natural and social sciences to improve the quality and quantity of safe vegetables produced by farmer communities in Cambodia. Although some human and financial resources were provided by the HARE-Net project to develop community capacity, they were not enough. The inclusion of the SISGs into the overall project provided additional resources to develop both a formalized social structure for learning and a platform for community members to amass capital, which could later be lent for investments in 'locally-tested' hard technologies that showed promise to increase household farming income. Perennial problems with development projects arise when technologies from well-meaning foreign scientists are introduced with attendant subsidies. Outcomes from such interventions often result in increased profits for farmers through the project's term. However, more often than not, the use of these innovations tapers off once the project ends, often because they are not affordable or locally sourced. In other words, the gains realized are often unsustainable. The reasons for this are manifold, but one underlying reason is based on approach. In most agricultural development projects, modernization theory (Moyo, 2009) is called on to introduce hard technologies aimed at increasing production and yield. Little thought is given to the social and cultural milieu in which the technology is introduced. In this case study, human development theory (Sen, 2001) was manifest in the SISG's collaborative learning activities and shows promise for sustainable outcomes—for example, savings, lending, new systems of production, contracts for marketing, and so forth—as the community, with U.S. and Cambodian university support, banded together to solve jointly identified problems.

5.1 The Potential for Participation and Social Learning to Help Identify Fertile Ground for Spawning Change in Agricultural Systems

One measure of improved economic growth within value chains is the progression through the generalized categories defined for groups of smallholder farmers with varied access to technologies, financing and access to markets. Among the farmers in SISGs, non-commercial farmers and commercial farmers with loose value chain connections dominated. None were commercial farmers with tight value chain connections with any advantage in the marketplace over other farmers. It is notable that the farmers who self-selected to lead development of new innovations with potential to improve their position within the value chain were farmers who already had some ties to commercial production. These farmers were willing to try something new because they saw potential to develop new and stronger value chain connections. One farmer verbalized the sentiment shared by many farmers that this project offered a unique opportunity to incorporate a promising technology into their community because "many NGOs tried many things but never had any success because they would leave. I consider this project a success because during the project the [project team] worked together with us to do things together." The lead farmers who participated in this process improved their position within the value chain and transitioned to commercial farmers with improved access to technologies, financing and strong market connections. While non-commercial farmers saw potential to use their increased access to financing through SISGs and enter into commercial production for the first time, all waited to see how the new technology would integrate into the existing system before investing in this new idea. It was clear that non-commercial farmers were less willing to take on new risks than farmers who already had some commercial production. This differential in the sensitivity to risk among smallholder farmers has implications for development projects and funding agencies. While considerable focus is given to improving agriculture for sustenance farmers, a strategy to accomplish this may be to focus on integrating improvements into local systems for farmers with relatively more resilience to absorb the ebb and flow that naturally occurs as systems change. It may be fruitful to initially work with less-poor smallholder farmers because of their relatively greater ability to take on risk and to be models for sustenance farmers.

A follow-up study is required to evaluate if SISGs and their associated communities have scaled up in the following six ways (Uvin & Miller, 1996) after the interventions that have taken place:

- Spread: What are the numbers of new farmers using the practices that were first introduced through the SISGs?
- Replication: Have there been new SISGs formed?
- Horizontal aggregation: Have groups merged to form larger farming collaboratives?
- Vertical aggregation: Have ministerial or agricultural institutions embraced this new model as part of their outreach?

- Functional integration: How has the practice of adoption and adaption of new technologies and practices continued among SISGs as compared with non-affiliated farmers?
- Sectoral integration: Have there been unrelated new activities or businesses added to the original SISGs structures?

The answers generated from such a study would provide a working model for the ways SISGs might contribute to scaling up a sustainable community-based agricultural economy.

6.0 Conclusions

This case study described a systems approach that addresses how development practitioners can engage smallholder farming communities to improve food safety within the food system by adopting technology in ways that increase rural livelihoods and promote greater collaboration among previously disaggregated stakeholders. The model offers a way to link private and public sector actors through the social platform of savings groups to (a) address critical development objectives in manageable increments that incorporated the knowledge base of local experience, (b) equip local leaders to manage changes, and (c) incentivize expansion within local social structures to sustain change. The approach was developed in response to the belief among the global agricultural development community that the promise of poverty alleviation, global health and good nutrition rests in the hands of smallholder farmers and the communities in which they work and live. The observations of this case study offer the promise of scalability and possibility for alternative development practices that can integrate sustainable changes into agricultural community development. While the approach focused on the community members involved in Cambodia's nascent safe vegetable value chain, it is a broadly applicable to a wide range of development concerns.

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