Report on Project Activities: Rural Investments in Agricultural Technologies

Timeframe: September 2013- September 2014

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Agricultural development in Cambodia

According to USAID's Feed the Future analysis, "Cambodia's underdeveloped agriculture sector has the potential to be a strong engine of growth." Despite such a potential, Cambodia agriculture is characterized by its low competitiveness when compared to neighboring countries. Even with high local demand for products to supply supermarkets, restaurants and hotels, up to 70% of all vegetables sold at Phnom Penh markets are imported. The potential for local farmers to increase their market share at present remains untapped. Major constraints in vegetable production are: i) limited access to credit and education among smallholders, ii) high risk, iii) inadequate agricultural extension and iv) poor collaboration among value chain actors. As a result of these factors, smallholder farmers adjust their production to less risky and lower skilled practices that require minimal inputs and cooperation. The result is typically reduced profits and competitiveness.

Project focus: Agricultural education and extension via savings groups

In collaboration with researchers and educators from the University of California Davis, the Royal University of Agriculture and Oxfam America, a two-year pilot project to form savings groups with vegetable farmers was initiated in summer 2012 under funds from the Horticultural Innovation Lab at UC Davis. The project was designed to examine the following questions:

i) Do savings groups fit the conditions of vegetable farmers?

ii) Can they serve as a platform to deliver education on agricultural technologies?

iii) Does this lead to an increased adoption and adaption of these technologies?

iv) How can ionformation sharing to and between farmers be improved?

Why savings groups provide a good platform for learning

Savings groups enrich rural communities by enabling members to access financial options such as credit, personal savings and insurance benefits. These services are delivered in a manner that is appropriate to the local cultural and economic settings as the groups are governed by the members themselves. Ideally, this leads to a grassroots movement of community development and cultivates a strong and independent community through economic and social solidarity from within. Savings groups provide a platform for a learning process through which individuals can engage in active participation and experiential learning.

Savings groups can be used as a platfrom for the promotion of agricultural technologies. However, such efforts can quickly become supply-driven, rather than demand-driven, by pressuring or incentivizing the adoption of undesired and inappropriate technologies. Such non-demand driven efforts typically fail. Therefore, the methodologies to deliver agricultural education must be selected to maximize the participation of farmers. A project can provided the platform for education, while most importantly the farmers and their needs guide the direction of research projects, workshops and excursions. It should be the farmers who decide upon which technologies they want to learn about, and how those technologies need to be adapted to fit the local context. By November 2013 most of the savings groups were 6 months old, so workshops and activities on agricultural technologies and best practices were organized from then on.

Picture 1: Vegetable farmers on a field trip to the Phnom Penh Aeon Mall

Project Location and Farmer Profile

The project was implemented in 6 villages in S'ang district of Kandal province, roughly 1 hour south of Phnom Penh. This location was chosen because it is a major vegetable growing region that supplies Phnom Penh markets. To gain a deeper understanding of constraints and opportunities for local smallholders in vegetable value chains , a survey with 144 households and focus group discussions were conducted in all villages. A list of all vegetable farming households was compiled with the village chief and a random sample was drawn from this list. The focus of these talks and surveys was to understand which topics are important to farmers and to learn which sources they tap for which information.

The farmers who live in S'ang are primarily smallholders who grow commercially. Main crops grown are leafy greens like mustards and kales. These vegetables have two major advantages for the farmers: i) they have a short crop cycle and ii) the short shelf life of leafy greens gives Cambodian farmers an advantage over imports from Vietnam or Thailand. The main challenge that the farmers face with growing leafy green vegetables is pest pressure that comes from a lack of crop rotation and poor pest management. This pest pressure has led to the widespread misuse of chemical pesticides. In many cases, crops are sprayed 2-3 times a week with a cocktail of pesticides, many of which have labels in foreign languages. This not only results in unsafe vegetables being sold to the consumer, but unknown environmental damage to the soil and water quality and health risks to farmers and their families. In Focus Groups, farmers themselves identified pesticide overuse as one of their biggest concerns. Summarizing information from thwe surveys we can characterize smallholder households (See Annex A for detailed results):

I) Arable land per household is 0,5 ha on average.

II) Low educational level of heads of household, 20% illitearcy, only 45% have completed primary school.

III) On average the heads of the household are 50 years old.

IV) Farming is main income for smallholders; 30% percent have off farm income.

V) Specialization on 1,7 crops per household on average.

Acces to agricultural information

As part of the surveys, the farmers were asked to select 5 agricutural topics out of 11 that are most important to them. The farmers The whole list of topics form which farmers could chose consisted of following topics: finance, soil, fertilizer, seeds, crop protection, desease, pesticide application, marketing, postharvest, weather, water. The ennumerators presented pictures that described the topics to illustrate the meaning of the question. Table 1 gives an overview of the results from this question.

78% of all farmers picked seeds, 74% picked pesticide application and 61% picked marketing as a topic of interest. The importance of pest control has to be rated higher though if we accumulate the picks for pesticide application and plant disease. Weather, postharvest and crop protection were the least picked by farmers and werent chosen by 20% of farmers. Interestingly the topic finance had the highest score of picks in round one (41%), which gives a hint at the importance of this topic to farmers.

Table 1: Important agricultural topics selected by vegetable farmers in S'ang

Topics	Pick 1	Pick 2	Pick 3	Pick 4	Pick 5	TOTAL	PERCENT
Seeds	22	39	22	16	14	113	78
Pesticide application	10	17	31	26	23	107	74
Marketing	14	20	13	17	24	88	61
Fertilizer	3	11	17	31	19	81	56
Soil	21	19	16	11	11	78	54
Finance	41	8	5	7	14	75	52
Plant disease	12	11	14	13	14	64	44
Water	10	9	20	8	10	57	40
Weather	4	2	3	8	10	27	19
Postharvest	4	5	1	6	3	19	13
Crop protection	3	3	2	1	2	11	8

Table 2 gives an overview on sources that have available to get informatin for the topics of interest they selected. The local input supplier plays the most important role in this and was named 286 times to be the source for agricultural information. Most notably is that farmers receive information for all topics from this source. The scond most imprtant source are lead farmers with 119 farmers tappiung this source for all topics.

Table 2: Sources of information of vegetable smallholders in S'ang

Topic/ Source	TV	Radio	Input supplier	NGO	Public extension	Mobile phone	Collector	Smart device	Lead farmer	Savings Club	Bank/ MFI
Finance	2	0	10	0	0	1	2	0	7	9	19
Soil	5	1	3	8	0	1	7	0	4	0	0
Fertilizer	5	6	53	7	0	3	3	0	13	2	1
Seed	5	1	84	7	0	3	9	0	22	1	1
Crop protection	0	0	4	1	0	1	2	0	4	1	0
Plant disease	6	3	36	7	0	1	1	0	16	3	0
Pesticides	9	4	81	5	0	1	5	0	22	3	0
Marketing	4	2	3	0	0	13	53	1	16	4	4
Postharvest	1	0	3	0	0	0	5	0	6	0	0
Weather	8	1	2	2	0	0	1	0	4	1	0
Water	1	2	7	3	1	1	0	0	5	3	1
TOTAL	**46**	**20**	**286**	**40**	**1**	**25**	**88**	**1**	**119**	**27**	**26**

The third most important source are the collectors which were named 88 times, but the majority of farmers (53) receives exclusively information on marketing. Other sources of information are TV which was named 46 times, NGOs (40) and savings clubs. Among information technologies, TV ranks first with 46 nominations , followed by mobile phones with 25 nominations and Radio with 20 nominations. Smart devices were only named once and rank very low, as well as public extension services.

With this background information, eductional methods for for workshops and tarinings were designed to suit the needs of the target group. The main points were:

I) Seeds, pest control and marketing were topics of most interest to farmers.

II) Educational methods have to be suited for illiterate people.

III) Mobile phones are the most commonly used ICT to get agricultural information.

IV) Lead farmers, input suppliers and collectors are the most important sources of information to farmers

Timeline

Table 3 gives a brief overview over project activities.

Table 3: Overview of project activities

	2012			2013												2014									
Activity	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
Identifying project villages	■																								
Focus groups		■																							
ToT savings groups			■	■																					
Identify neighborhoods					■																				
Household surveys					■																				
On campus trials on technologies				■	■	■	■	■	■	■															
Promotional meetings savings groups						■	■	■	■	■	■														
First saving are collected in Box							■																		
Data collection savings groups										■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Technology Fair														■											
Redesign nethouses															■										
Implementation of field trials																	■	■	■	■					
Evaluation workshop																					■				
Workshop marketing																							■		

Savings groups formation

A savings group is a group of people who meet regularly to save money and use the group savings to give loans to their members. While the concept is simple, the success of a savings group depends on six crucial components, namely:

i) All members in a group know and trust each other.

ii) Comprehensive training and follow-up over the course of the first year by an experienced savings group facilitator.

iii) Decision making on rules and regulations with consent of the whole group.

iv) Transparency in electing board members.

v) No external incentives and subsides are given.

vi) All materials, specifically a cash box, a lock, and accounting books for bookkeeping, are purchased by the group.

Once a group has functioned for a minimum of 6 months it is possible to introduce trainings on other topics. Before then, the group is still learning how to effectively hold its weekly meetings and it can be overwhelming to receive additional trainings, especially when conflicts and uncertainties still exist inside the group. Table 4 gives a short overview on data of 11 savings groups that were formed in March 2013. The data was collected on a monthly basis over one year until August 2014.

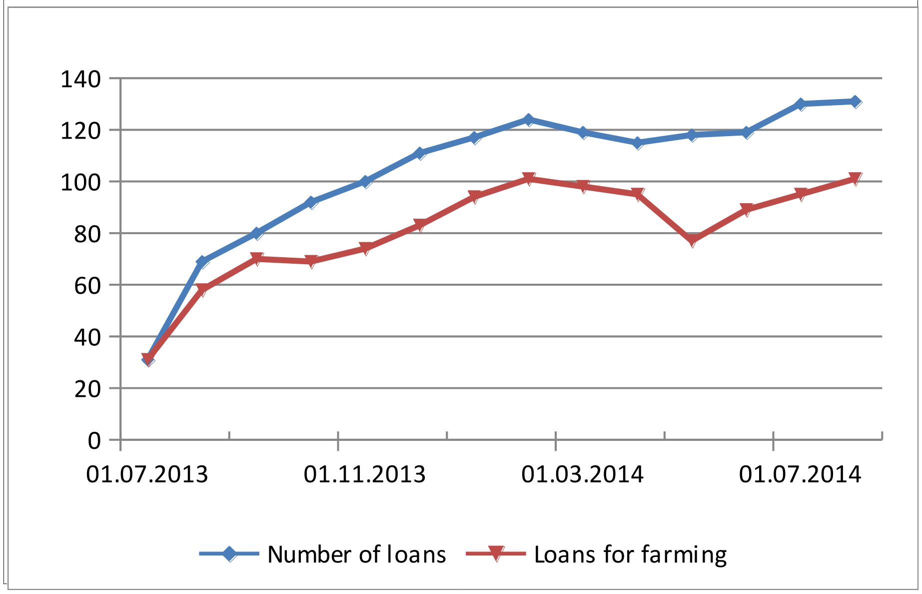
Table 4: Group composition and financial data from 11 savings groups in S'ang district

Members	199
Female Members	166
Value of savings	31.627 USD
Cash in Box	4.849 USD
Social Fund	246 USD
Value of loans outstanding	28.697 USD
Total Loans for farming	60.775 USD
Number of loans outstanding	101
Loans for farming	131

In total, the savings groups had 199 members. The majority were female members. In Cambodia, women are traditionally responsible for the household economics. The promotion of savings groups was especially addressed to women, but membership in savings groups was seen as a family membrship, and husbands and kids were invited to workshops, especially if they were engaged in vegetable farming and directly affected by loans for farming. Many times we made the experience that important decisions, for example greater agricultural investments and loans, need the approval of the whole family.

The total value of savings of all groups surpassed 31.000 USD after one year, which is equal to 3 USD of savings for each member every week. In total, 131 loans were given for farming activities, excluding investments in livestock. These loans reached a total volume of 60.00 USD. The steep incline in savings and loans is a sign for the high acceptance of the savings groups among members. The groups learned quickly to develop a protocol of weekly meetings transparent to all members. Especially for farmers in vegetable value chains, the savings for change methodology is a very good fit. The relativelys short cropping cycles of around 40 days enable a dynamic flow of cash. Farmers prepare their land, buy seeds and fertilizer on a regular bassis, and produce is sold easily 9 times a year in bigger bulk to the wet market. The savings groups offer a convinient and profitable way (3% interest per month) to deposit this money and take loans for further investments. Since vegetable farming in the project area is not dependent on external condition like rainfall, farmers act independent from each other. Thus demand for loans stays constant over the year. Figure 1 shows that only at the onset of the rainy season the groups took out less loans because farming is reduced due to flooding.

Figure 1: Total number of loans and number of loans for farming activities



This effect of seasonality can also be observed in the amount of cash that is deposited in the box, which is increasing at the onset of the rainy season, while the value of loans outstanding decreases (see Figure 2). This decreased demand for loans is only apparent in March and April and already in May loans pick up again. It is important to note here, that the groups agreed on terms and conditions for loans at the beginning of the season and low limits for maximum loan sizes were set. This is due to the fact that farmers first need to learn about financial capacities of the other members before they can make a well informed decision on loaning comparatively huge amounts to one family. The maximum loan size was around 150 USD in the first cycle. All groups raised the maximum loan level per household after the first cycle was completeted to guarantee loans up too 500 USD.

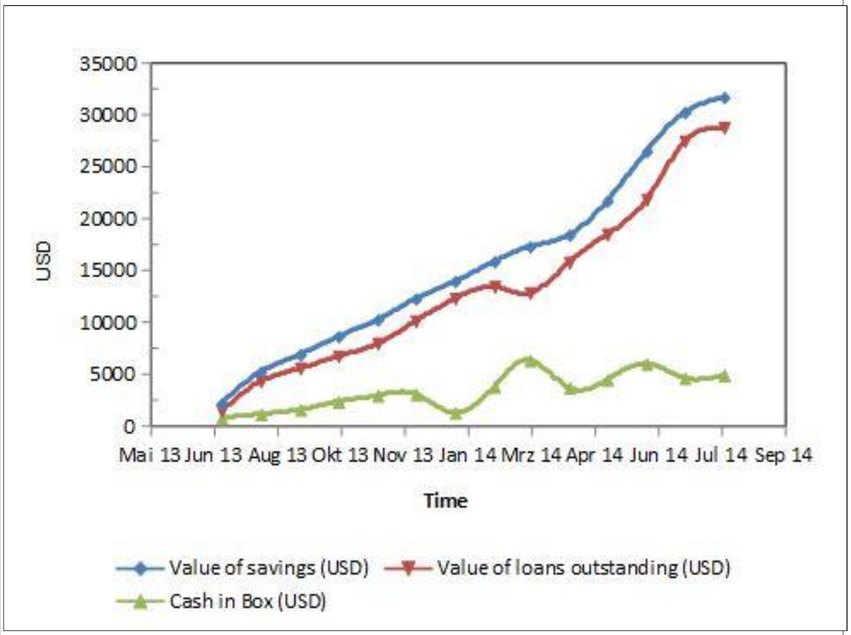


Figure 2: Value of savings, value of loans outstanding and cash in the box over time

Technology Fair for farmers at RUA

On November 24th 2013, the project organized a workshop that brought 39 farmers from 12 savings groups and 11 Phnom Penh-based vegetable shops and wholesalers together at the Royal University of Agriculture. The objectives of this workshop were i) share information on market demands, prices and vegetable production constraints, ii) demonstrate agricultural technologies that can support safe and more profitable vegetable production and postharvest, and iii) selection of promising technologies for further experimentation.

The technologies displayed on the university's research sites were: low net tunnels, soil solarization, cool storage using a Coolbot, drip irrigation, solar dryer, drying beads, and composting. After observing a demonstration, the participants of the workshop were asked to vote on the technologies that were the most relevant to their farming practices and needs. The low net tunnels were selected and the group agreed to use this technology for further experimentation on campus and more importantly in the villages. The farmers discussed pros and cons of this technology and they expressed their concern that the net tunnel is too low and impractical because it only covers a single row. What farmers had in mind was a bigger structure; this idea led to what we now call a nethouse.

The adoption process of agricultural nets

After the technology fair, 3 farmers who expressed interest were invited to RUA to design the nethouse. Their main concern was that the low tunnels make irrigation and weeding difficult. The farmers conveyed that they need a design that covers multiple rows and allows them to enter the structure to perform farming activities. A nethouse was designed that stood 2 meters tall and covered several rows. After the first nethouse was built on campus, adjustments were made to reduce the amount of netting per structure and to improve the materials used. High quality polyethylene nets were procured from a Vietnamese company that has a Cambodian distributor. The nets have a UV coating and a mesh size of 32. The improved nethouse covered 40m^2 (four 10 meter long rows) and cost 60 USD for materials. For field experimentation and demonstration 9 improved nethouses were built. Bamboo was used for the frame because it is a widely-available, low-cost material that farmers can cut themselves or purchase in local markets.

Picture 2: The evolution of nets: Low tunnels at RUA (left) and improved nethouse that was built on 9 farms (right)

Implementation of field trials

Shortly after the conference, the project team visited 3 villages to follow up on the discussions that were started at the conference. Nine farmers volunteered to donate land and labor to install and maintain a demonstration site at their farm. The nethouse was loaned to the farmers for the duration of the experiment. Also provided by the project were compost, manure and seeds to demonstrate alternative inputs as an integral part of the educational modules. The marketers compiled a list of vegetables that they guaranteed to purchase if grown chemical-free inside the nethouses. At the beginning of the first cropping cycle, a set of introduced crops of tomatoes, European kale, arugula, romaine lettuce, basil, cauliflower, mizuna and heat resistant Chinese cabbage were offered to farmers and the farmers chose which of these introduced crops they wanted to grow in the nethouses. Later on, the farmers were able to freely select whichever seed source and variety they wanted to grow in the nethouse, but at least each farmer had some experience with the introduced crops. In order to maintain support and regular communication with the nethouse farmers, 3 RUA undergraduate agronomy students were hired to visit farmers on a daily basis. Their tasks were to maintain the nethouses, explain characteristics and production needs of the introduced crops and to facilitate the communication between farmers, researchers and market actors.

Marketing of chemical free vegetables

An important part of the field trial was to test the marketing of vegetables that were grown under nethouses. The main research questions were: Can the nethouses produce vegetables that achieve higher market prices? Which markets would be interested in such produce? How can we organize transportation and who bears the cost? What is the market demand for safe vegetables? Farmers in S'ang almost exclusively sell their produce to wholesalers from two wet markets in Phnom Penh and Tha Kmau, either directly or through a collector. A rising alternative to these outlets are small vegetable shops which offer a higher product quality, namely safe, chemical-free and organic vegetables.[1] These shops most commonly collaborate directly with farmers or grow vegetables themselves on small market farms. In total we invited 11 marketers to the workshop, both from wet markets and small vegetable shops. Table 5 displays the main characteristics of both market types.

1 The labels “safe”, “chemical-free” and “organic” are used loosely in Cambodia as this nascent sector of the vegetable market develops and a trusted certification system is formed. Generally speaking, safe vegetables can be grown with chemical pesticides and inorganic fertilizers that are used correctly, though preference is given for organic fertilizers and natural pesticides. Chemical-free and organic vegetables are grown using only organic fertilizers and natural pesticides.

	Small vegetable shops	Wholesalers at wet markets
Quantity of produce	100 kg fresh vegetables of different variety per day.	500 kg of fresh leafy green vegetables bought in bulk every 40 days.
Quality of produce	High quality, chemical free production.	Low quality from conventional production and no restrictions on chemical inputs.
Transportation	Direct transport to shops via remork.	Wholesaler organizes transport with Moto's and Trucks.
Storage	No big storage facilities with cool storage, evaporative cooling at one shop.	Delivery directly to wet markets where produce is sold to retailers.
Prices	2600 Riel (0.65 USD) per kg on average, between 1500 Riel for Chinese greens and 7000 Riel for Cauliflower. Stable prices.	Average prices around 800 (0.2 USD) Riel per kg, from 300 Riel to 1700 Riel. High price fluctuation.
Relationship to farmers	No relationship to farmers in S'ang, buy produce from own farm or contracted farmers in Svay Rieng.	Frequent interactions with farmers, long term relationships.

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During discussions, the wholesalers indicated they:

I. Generally buy around 500 kg from one farmer at a time.

II. Were not interested in buying smaller amounts of vegetables.

III. Were not demanding broad product variety but seemed to be specialized on just a few varieties.

IV. Had no outlets that give them a premium for chemical-free or high quality produce.

V. Had no adequate infrastructure for storage.

Additionally, prices in the wet markets are characterized as highly fluctuating. Every crop could be a loss or a big gain to the farmer. It is suspected by the project team that most farmers in conventional production experience 4-5 losses and perhaps one big gain annually. Farmers themselves jokingly compare agriculture to playing the lottery. In contrast to the wholesalers, the small vegetable shops saw the potential of the nethouse technology to ensure the supply of chemical-free vegetables that would easily gain trust among consumers. The main challenge in establishing this market for farmers was that the shop owners had no prior relationship to the farmers; initially it was up to the project to facilitate good communication between farmers and market actors.

Use of Information and Communication Technology (ICT)

A tablet computer was bought to improve communication channels on all levels and to test ICTs in agricultural extension. This technology enabled the students to i) share media of good agricultural practices among farmers, ii) collect and enter agronomic data on performance of crops and to iii) disseminate information on all levels, namely between researchers at RUA, farmer groups and market actors. The students used a Facebook group to post their results and questions. This Facebook page also enabled frequent contact between farmers and marketers. The students would post pictures of the crop a week prior to harvest, with an amount of harvest estimated. The marketers could see the quality of the produce and would post under the picture their purchase request and contact information.

Figure 3: Students communicate desease problems (left) and market markteing (right) via Facebook

Results of the field trial

It is important to note that the data displayed here is not intended to claim any scientifically significant results. It is merely a way for the project team to understand the practices of vegetable farmers. The data helped us to enter into a discussion with farmers about constraints and opportunities of their practices, and the field trial provided good estimates about revenues and prices of production. The average results from 58 crops that were grown in the nethouses in the first 3 months of the experiment (June-August 2014) are displayed in Figure 7, alongside 9 crops that were grown by the nethouse farmers on open beds in a conventional way.

	Cropping cycle [days]	Area planted [m²]	Average yield [kg]	Average yield per m²	Average price [Riel]	Average revenue per cycle [Riel]
Total (n=58)	45	13.5	11	.9	2.650	33.000
Traditional crops (n=46)	36.1	11.2	13.1	1.2	2.821	35.000
Introduced crops (n=12)	71	18.4	5.1	0.2	2.233	27.000
Conventional production, open beds (n=9)		3400	1587	.46	.800	

Table 6: Agronomic and economic data from the field trials

The data shows that crops grown under nethouses yield around 1 kg/m^2 and are sold on average with a price per kg of 2.650 Riel (0.66 USD). On average, one single crop is planted on 13m^2. In comparison to this, one single crop in conventional production was grown, on average, on 3,400m^2. The yield from the conventional leafy green crops averaged at 0.46kg/m^2 , significantly lower than the average yield of nethouse vegetables. The conventional crops were exclusively sold through the wholesalers, so it would happen from time to time that not all of the produce was sold to the market. To add to this challenge, the farm gate prices changed from day to day. From our experience it became clear that in this exchange the wholesalers have the upper hand. This is manifested in market prices ranging from lows at 292 Riel/kg to maximum prices of 1700 Riel/kg (0.425 USD), bringing the average to 0.800 Riel/kg (0.20 USD). It is interesting to note that for conventional production, farmers spent 53% of their total revenue from these crops on pesticides.

The data is further partitioned into traditional crops and introduced crops that were brought by the project. Crop comparsion is difficult though as the duration of the alone differed significantly. For example, introduced crops needed 71 days to harvest and traditional crops averaged just 36 days. The yields of introduced crops were comparatively low, which shows that learning about new crops comes at an initial cost of low production, until practices are well adjusted. Nevertheless, an important observation was that introduced crops did not only require special agronomic attention, but also special marketing needs. For example arugula is not well known in Cambodia, so it was difficult for the small vegetable shops to sell to

Cambodian customers. Only one small vegetable shop had a relatively high expatriate customer base, so they were able to sell arugula at a high price: 6000 Riel/kg (1.50 USD/kg).

Developing an investment plan

With the experience gained from growing vegetables in nethouses and the data from the field trials basic cost and benefit calculations were made. The objective was to develop a business and marketing strategy that included the nethouses. These business plans then served to create an investment scenario as close to an individual farmer's reality as possible, which they could then use to make a well informed decision about investing or not investing in nethouses.

Table 4 displays the results of a calculation on the returns of investments for a 160 m^2 nethouse. The total cost of buying a 160m^2 nethouse, including all transportation and labor costs, is 500 USD. The life expectancy of the UV coated net material is 5 years, so this is included in the investment calculations to ensure that farmers are able to re-invest when necessary. Furthermore, we calculated a lump sum of 10 USD per month for diesel for the water pump, seeds, fertilizer and general repairs. Even though these costs vary over the course of the year and some of the costs are directly linked to vegetable production, we made our calculations in lump sums for the sake of simplicity. Estimates of yields are based on the assumption of 1kg/m^2, leading to a total production of 1,280 kg per year. An exception is given for the first year, where we did not calculate yields for the first two months of production because farmers need to slowly start production and cannot use the full space inside the nethouse from the beginning. The overall production for this first year is 1,066kg. Our experience shows that farmers can grow 9 cycles per year and even more if additionally they use germination tables to shorten the season. In these calculations we preferred to use conservative values to avoid overestimating yields and revenues, so we based them on 8 crop cycles per year. We assumed a stable market price of 2000 Riel/ kg (0.50 USD/kg), even though this is typically the minimum price for chemical-free leafy greens and higher prices can be achieved. A break-even analysis showed that for this investment a minimum price of 1200 Riel/kg (0.30 USD/kg) is needed to break even after 5 years. The investment shows a 90% return on investment and a net profit of 1,992 USD.

Based on this data, a farmer can make around 400 USD on a 160m^2 nethouse per year, significantly more compared to a typical annual rural income of around 1,000 USD.

	USD	Details
Initial investment	$ -500	160m² nethouse sales price
Total cost per year	$ -120	10 USD per month, water seed, fertilizer, repair
Revenue year 1	$ 412	Yearly production: 1.066 kg, market price 0.5 USD/kg
Revenue year 2-5	$ 520	Yearly production: 1.280 kg, market price 0.5 USD/kg
Net profit	**$ 1992**	
ROI	**90%**	

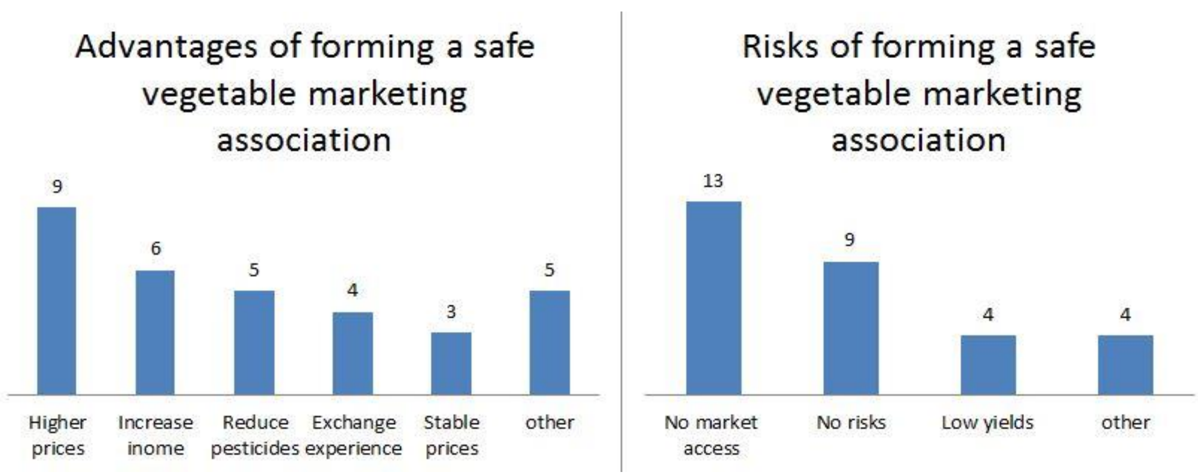
Table 7: Investment plans for nethouses (160 m2 in size, 5 years life expectancy)

Developing a business model

After seeing that the nethouses produce good agronomic and economic results, the pressing issue was to develop a business and marketing model. Since each experimental nethouse had a size of 40 m^2, the 9 farmers who participated in the experiment had to synchronize their crop rotations to guarantee a constant supply of many varieties of vegetables. This required good communication among farmers and with marketers. During a follow-up workshop, the farmers developed a model for a marketing association of nethouse vegetables. The main drivers behind forming an association are to streamline the crop production and supply to the market. One vegetable shop demands 100 kg/ day so we estimate that the annual demand for fresh, chemical-free vegetables is up to 365,000 kg for one small shop. To meet this demand approximately 3,250 m^2 of land under nethouses is needed. Furthermore, a high variety of produce has to be guaranteed; the ideal scenario being 10 kg of 10 different kinds of vegetables. This amount of supply can only be managed by a group of farmers, mainly to reduce the size of the investment and the risks that come with it.

To clarify the willingness to invest in nethouses and to form a marketing association, a survey was conducted with 26 farmers who attended the workshops on the nethouses. We asked them if they are interested in investing in a nethouse on their farm: 17 answered yes, 5 farmers said no and 4 said they would like to wait and see how things develop. This result confirms the positive view that farmers have towards this technology. When it comes to size of the nethouse, 8 farmers were interested in purchasing a nethouse of 500m^2, 11 farmers opted for a 160m^2 nethouse, and only one farmer showed interest in the 40m^2 nethouse. Regarding the time of investment, 9 farmers said they could not invest money, 4 farmers could invest up to 100 USD, 9 farmers between 100-300 USD and 4 farmers were willing to invest more than 300 USD. This is due to the fact that most farmers had already invested money into something else- 20 out of the 26 farmers surveyed had loans outstanding to their savings groups. Looking at the savings groups as a source for investments, 17 farmers stated that they can take a loan over 300 USD, whereas 9 farmers said that their group would not give loans higher than 300 USD. Many farmers state that they wouldn't necessarily loan only from the group but also tap other sources to compile large investments. It becomes clear that savings groups can grow to become an important piece to the houshold finances but that they also have limitations. Ideally these limitations are complimented by other financial tools like MFIs or loans among family members.

Looking at the market demand and assuming that most farmers would be interested in a 160 m^2 nethouse, it can be derived that 20 farmers are needed to build a nethouse of 160m^2 to reach the market as an association.26 farmers were asked what they see as advantages and risks of forming a producer association. The results of this survey are displayed in Figure 8.



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The advantages directly linked to farm economics were cited most often, namely, higher (9) and stable (3) prices, lower use of pesticides (5) and a general increase in income (6) through nethouse production. Regarding risk, the most prominent concern that farmers had was lack of market access (13). This survey made clear that farmers were cautious about investing in nethouses if they could not be sure of a long term purchasing agreement with the small vegetable shops or other similar markets. We believe that having a guarantee from the market is a crucial point for farmers in their decision to invest in new technologies in general, not just nethouses. Otherwise the uncertainties and risks of adopting new practices and using new tools outweigh the potential benefits of the technology.

The adoption of nethouses and new business strategies

Benefits and risks as well as advantages and disadvantages of the nethouses were discussed with the farmers. The approach always was to stay objective and hear the voice of the farmers, to let the group guide itself through the process of innovation and experimentation. It must be stated that our project staff started to deeply believe in the positive benefits and the economic viability of the nethouses. These opinions might have influenced the answers that farmers gave in interviews and discussions since they did not want to disappoint project staff and avoid confrontations. Therefore we have to be careful in interpreting the results that are presented above.

Out of the 9 farmers that had an experimental nethouse on their farm, 2 invested in larger nethouses after the workshop in August. One farmer invested in a 525 m^2 nethouse, while the other farmer opted for two 160m^2 nethouses. In total 845 m^2 of nethouses were built between August and December 2014. The two farmers who did invest in nethouses signed 1 year contracts with one small vegetable shop in December 2014 and they are synchronizing their crop rotations to guarantee an even and diverse supply of vegetables. The average price for one kg of vegetables in their contracts is 3,400 Riel (0.85 USD), far surpassing the price we used for our internal calculations. The farmers quickly managed to organize themselves to supply the shop 3 times a week with of 65kg of vegetables, achieving a weekly total of 195 kg of vegetables. This number rose to 300 kg per week by the end of January 2015. At this rate, it is reasonable to assume that these farmers can produce 12,000 kg of safe vegetables a year (including lower production that is typical during the rainy season). This generates revenue of 4,500 USD for each farmer per year. One of the farmers is scaling up his nethouse production by building another nethouse of 480 m^2 by the end of February 2015.

Figure 5: 480 square meter nethouse built in January 2015

Lessons learnt

- Participative methods lead to increased feelings of ownership among farmers over project activities and their direction.
- Only farmers that had demonstration sites adopted the technology, experiential learning increases early adoption of technologies.
- ICTs foster information exchange and are adequate especially when working with students.
- A stepwise approach of introducing new technologies and practices is crucial so farmers can realize impacts of each component.

- Agricultural technologies and innovations need to be embedded into business plans which are developed by farmers.
- The introduction of agricultural technologies requires a shift in cropping systems and marketing channels.
- Savings groups are an excellent fit to disseminate information and to provide capital for investments in vegetable value chains.
- Savings groups are an adequate financial tool for smallholder vegetable farmers and enable agricultural investments.

Figure 6: The Natural Agricultural Village Shop in Phnom Penh has become the major outlet of safe vegetables grown by farmers from savings groups of Kandal province.