

**PERCEPTIONS OF RISK AND RISK MANAGEMENT STRATEGIES: IDENTIFYING
ALTERNATIVE STRATEGIES TO PROMOTE SMALLHOLDER VEGETABLE
PRODUCTION IN CAMBODIA**

**Sean Kiely¹, Karen LeGrand¹, Thort Chuong¹, Kristin Kiesel¹, Cary J. Trexler¹, Borarin
Buntong², and Glenn M. Young¹**

¹University of California, Davis, CA, USA

²The Royal University of Agriculture, Phnom Penh, Cambodia

ABSTRACT: *Cambodia's vegetable sector is typically poorly managed and susceptible to a multitude of shocks preventing producers from meeting consumer demand. Thus, consumers rely on imported vegetables from Vietnam and Thailand. The government of Cambodia is intent upon capitalizing on this demand for domestic vegetables and has shown support for farmers and marketers shifting toward the vegetable sector. However, the government must work quickly if it wishes to assist its growers in capturing this market. Farming is inherently risky as farmers are faced with numerous exogenous factors that can alter yields and farm income. The implementation of risk management strategies tailored to the risk-taking behavior of the farming population can significantly reduce the impacts of these exogenous shocks. This study assesses existing vegetable grower's risk management strategies, their knowledge and perceptions and find that the accessibility of producer groups, savings groups, crop insurance, and contract farming can greatly mitigate the risks deemed most significant by growers. These strategies will likely exhibit high rates of adoption and can significantly reduce risks and farm profit losses. Finally, we recommend the establishment of a crop insurance program by the government as well as an overall policy environment in which contract farming can thrive in order to support vegetable growers and meet the countries growing vegetable demand.*

KEYWORDS: risk, risk management, Cambodia, vegetable production, crop insurance, contract farming

INTRODUCTION

In Cambodia, 20.5% of the rural population live in poverty and are vulnerable to even minor economic shocks. Vulnerability to shocks is of particular concern in the agricultural sector as approximately 65% of the total population is engaged in agricultural production (Asian Development Bank, 2014; FAO, 2014). Exogenous shocks like pest pressure, drought, and access to water particularly affect the livelihoods of Cambodian farmers impact their revenue streams post-harvest. Farmers in Cambodia are also exposed to market risks as they are subject to extreme price volatility for their crops and often lack access to financial services to acquire loans. Financial market linkages are often weak or non-existent, financial literacy among farmers is low, and

farmers lack acceptable collateral needed to acquire capital improvement loans (FAO, 2014). It is of paramount importance to facilitate risk mitigation practices in order to lower risk exposure and increase the economic viability of Cambodian farmers.

Vegetables are the most profitable crops to produce and generate greater income for rural farmers while concomitantly providing positive nutritional benefits to consumers (Eliste, 2015). However, Cambodia's existing vegetable sector "is underdeveloped, poorly managed, unreliable and affected by seasonal climate variability. Cambodia therefore relies on cheap imports from neighboring countries" (Sophal, 2009). The Cambodian Agricultural Research and Development Institute estimates more than 75% of vegetables sold in the market are currently imported. Most of these imports comes from Vietnam. However, only 8.0-8.5% of Vietnamese vegetables grown meet standards for safe production set by the Vietnamese Ministry of Agriculture and Rural Development (MARD) (Moustier, Bridier & Loc, 2002; VietNam Bridge, 2009; Trexler, 2016).

Cambodian consumers lack confidence in the safety of imported vegetables, creating an opportunity for locally-grown vegetables to displace foreign vegetable imports (Kula, Turner & Sar, 2015). The University of California, Davis (UC Davis) has been collaborating with Cambodia's Royal University of Agriculture (RUA) since 2010 to help farmers and the produce sector with the development safe-vegetable value chains (SVVCs). The focus of the SVVC has primarily been to improve vegetable production practices, post-harvest practices, and market linkages. Production practices have also been restructured through participatory research (LeGrand et al. 2017; LeGrand et al. 2018). Improvements and practices include innovations such as soil improvement and nutrient management using earthworm compost, chemical-free crop protection from insect pests using nethouses, and improved post-harvest handling practices such as sorting, washing, packaging, cold-storage. Additionally, the program has established new market linkages that successfully connected producers and marketers through a branding campaign that promoted domestic, chemical-free vegetables. This advantageous branding reduced risk for farmers by creating a price premium for the products grown without chemical pesticides or fertilizers and to negotiate contract prices with marketers. The SVVC project has provided numerous "hard" or tangible technologies for growers to implement and has supported these hard technologies, the use of human-mediated "soft" technologies in the Kandal province including shared interest savings groups (LeGrand et al. 2018; Miller et al. 2017). Shared interest savings groups act as a mechanism of risk management because they supported growers in multiple ways. Participants in shared interest savings groups gain basic financial tools for managing community-based savings and loan programs. Also, the shared interest savings group platform builds social structures that serve as vehicles for collective community action to address agricultural problems. While the SVVC program implemented technologies and practices that established for the first time domestic supply chains for safe vegetables in ways that support farmers, it is necessary to expand the use of soft technologies to further support growers and provide additional income generation, financial assistance, and safety net services.

The focus of this research is to examine grower risks and risk management strategies (soft technologies) which can improve grower livelihoods and protect growers from the pitfalls of poverty. Specifically, the purpose of this study is 1) to understand the risks faced by vegetable producing farmers and their risk-taking abilities and 2) to identify human-mediated risk

management strategies that simultaneously promote economic viability and exhibit high adoption rates based on risk. High adoption is defined as the implementation and continued use. While some strategies may have high payoffs, risk aversion levels may lessen the likelihood of implementation and continued use. Therefore, we place an emphasis on strategies that garner high payoffs for growers while also exhibiting high rates of adoption based on grower risk-taking ability. We assess 1) attitudinal levels of risks faced on the farm 2) perceptions of risk taking ability 3) use, awareness, confidence, interest, and perceived benefits and risks of both traditional and alternative risk management strategies and 4) access to risk information and education for 30 smallholder farmers in two villages in Battambang province.

LITERATURE REVIEW

In this section, we review the literature regarding the dimensions of agricultural risks and the risk management strategies available to mitigate these risks. Here, we discuss the areas of risk most pertinent to Cambodia's vegetable sector and the strategies, divided into traditional and alternative strategies, most suitable in aiding growers.

Risk in Agriculture

Risk can be defined as "uncertain consequences, particularly possible exposure to unfavorable consequences" (Hardaker, 2004). Farmers face multiple dimensions of risk in agricultural production. These agricultural risks are associated with negative outcomes stemming from exogenous variables such as fluctuations in climate, natural disasters, and price volatility that are outside of the control of the farmer. To understand appropriate risk management strategies for farmers, it is important to understand the various dimensions of risk faced. While not exhaustive, the following dimensions of risk are the most pertinent to Cambodian agriculture that although not completely preventable can be mitigated at the farmer level.

Price Risk: The volatility of input and output prices is an extremely important source of agricultural risk. In particular, output prices for agricultural commodities can vary significantly. In segmented, local markets an increase in annual production typically decreases output prices, while a decrease in production leads to increased output prices. The instability of output prices makes it difficult for farmers to accurately predict profits, has severe consequences for the household's ability to plan financially.

Production Risk: The high variability of production outcomes in agriculture are due to the myriad of exogenous variables that effect production. These exogenous variables, including extreme weather conditions (i.e. flood, drought, fire, excessive heat and rain), changing input costs, and pests (i.e. insects, diseases), lead to uncertainty in crop yield and quality, which effects farm profits.

Financial Risk: Farmers need to finance business operations and maintain cash flows in order to meet financial obligations and repay debts. Many farming operations hinge on the ability to access and borrow loans. Borrowing money introduces numerous financial risks. The uncertainty of lenders to supply loans in the present and future is one source of risk. Additionally, the ability of farmers to pay back loans due to interest rates and future production and price risks effect farm cash flows (Drollette, 2009).

Marketing Risk: A lack of market information systems makes it challenging for farmers to assess demand for a product, search for and identify buyers. Market access can be limited by poor infrastructure and supply chains, and limited marketing strategies, which further reduces the number of buyers available for farmers.

Personal Risk: The health of the farming family and main farm operator are the primary personal risks faced by a farm business. Illness or death of the main farm operator or other members of the farm family can disrupt the performance of the operation. Labor shortages can be another source of personal risk. Labor shortages often occur during rural to urban migration as well as political and social unrest (Kahan, 2008).

Risk Management Strategies

Farmers often use a diverse set of strategies to manage the risks they face. Some strategies address a single risk while others can deal with multiple risks. This section defines intangible risk management strategies that are both pertinent to addressing the risks that Cambodian farmers face and potentially feasible to employ in current or near future management systems. We divide the risk management strategies into two groups: traditional risk management strategies and alternative risk management strategies. Traditional strategies are defined as “arrangements made by individuals or households or such groups as communities or villages”. Alternative strategies are defined as “market-based activities and publicly provided mechanisms” (World Bank, 2005). While there is some fluidity in these definitions (i.e. the categorization of producer groups), they characterize strategies as those that are traditionally available to farmers and those that are not. When assessing the appropriateness of risk management strategies, it is important to consider both ex-ante and ex-post forms of risk reactions, i.e. the reactions of an individual once an exogenous shock has occurred in order to better understand how they will likely be employed to mitigate the effects of a shock after it has occurred and the ability of these strategies to reduce the impact of a risk.

Traditional Risk Management Strategies

We evaluate the following traditional risk management strategies. These strategies are typically accessible in any farming community.

Off-farm Work: Off-farm work is a traditional strategy that mitigates the effects of agricultural risks on farm household income by supplementing agricultural income through a more diversified and reliable income stream. Off-farm work can be both an ex-ante or ex-post reaction to risk depending on the time of employment.

Precautionary Savings: Precautionary savings include liquid and semi-liquid assets in the form of cash, livestock, crops, tools and equipment, and other household assets. This traditional strategy is an ex-post shock absorbing mechanism used by smallholder farmers (Ullah, Raza, et al., 2015).

Vegetable Diversification: Vegetable diversification refers to the planting of multiple types of vegetable crops in order to reduce the risks of crop failure due to the exogenous effects of weather and pests as well as to diversify income to mitigate the effects of volatile market prices (Ullah, Raza, et al., 2015). As vegetable production is the main focus in this study, vegetable diversification

is considered a traditional risk management strategy that functions in the same way as crop diversification. Non-vegetable crops, however, are considered under enterprise diversification.

Enterprise Diversification: Enterprise diversification refers to the inclusion of several farming operations such as the production of multiple crops, livestock, aquaculture, etc. The main principle of enterprise diversification is to engage in operations that negatively or weakly positively correlate with each other. Therefore, if there is lower income resulting from one activity, it may be offset by higher income from another activity as the two do not move in lockstep with one another (Gunjal, 2016).

Social Networks: Traditional societies can protect against risk through strong community bonds, often supporting individual families in times of hardship. Social networks can operate as an informal social safety net when idiosyncratic shocks occur. Idiosyncratic shocks are shocks where “one household’s experience is typically weakly, if at all, related to neighboring households.” These shocks typically occur due to crop yield shocks within microclimates, localized pest or disease outbreaks, or one-off events such as flood or fires. However, social networks particularly in developing countries typically do not ensure against covariate shocks, meaning that “many households in the same locality suffer similar shocks.” Covariate shocks occur due to price instability, natural disasters, or financial crises (Bhattamishra & Barrett, 2008). Social networks can also extend lines of credit when formal credit institutions are not accessible.

Alternative Risk Management Strategies

We evaluate the following alternative risk management strategies. These strategies are not always accessible in farming communities, particularly in developing countries but they may provide large benefits once implemented.

Contract Farming: Farming contracts are arrangements made between buyers and producers that set a price and outlet for the good prior to harvest. These contracts secure a buyer and guarantee prices growers receive for commodities, thus minimizing market and price risks. In the context of this study, flat-rate contracts are offered to growers under the condition of producing vegetables in nethouses and eliminating the use of pesticides in the production process. This form of contract is a mix of a marketing contract and a production contract. The contract emulates a marketing contract in that it establishes a buyer and pricing arrangement. The farm operator controls most of the production process and owns the commodity while it is being produced. The production risks are therefore faced mainly by the operator. However, the contract also imitates a producer contract in the sense that the buyer/contractor has some control over the production process by specifying the use of nethouses and compost as well as the nonuse of pesticides. Flat-rate contracts negate future price risks and spread marketing risks while guaranteeing a minimum price. This minimum price provides market price protection for growers when open-market prices are low, but also means that growers potentially forgo upside market price potential. In cases when open-market prices are high, side-selling on the part of the producer may occur (ERS, 1999). However, we observe contract prices that are typically above mean market prices, largely mitigating the issue of forgone profit opportunities and side-selling. It is worth noting that financial literacy is often

low among smallholder farmers, which can pose a legitimate risk to producers as contracts must be clearly defined before entering into agreement.

Inventory Credit Systems: An inventory credit system (ICS) is an agreement between a storage facility operator and a grower who deposits a commodity of a specified quality and quantity in a secured storage environment. The grower is then issued a receipt for the deposit which can be used as collateral to obtain loans or to sell the commodity at a later period when the market price is at a more desirable level. The storage facility or warehouse typically functions either privately, publicly, or as part of a community inventory credit. ICSs can manage price risks by storing commodities when market prices are low and selling commodities when prices are acceptably high. ICSs also manage financial risk by offering growers a way to obtain credit they are often excluded from due to lack of collateral required by lending organizations. ICSs also reduce post-harvest losses by placing commodities in a secure, stable environment. However, several disadvantages exist as well. Lenders face the risk that borrowers will default on their loans. Creating suitable storage systems in rural areas is often prohibitively costly (Gunjal, 2016). In relation to this research study, vegetables require well developed cold storage systems for ICSs to function properly; however, in the study area such a system has only recently been introduced and is in experimental phases.

Crop Insurance: Crop yield insurance is used by growers to mitigate production risks when yield losses occur. Growers typically pay the insurer a fixed premium for protection from uncertain, but potentially large yield losses. When these losses occur, indemnities compensate the grower up to the insured coverage level. Coverage levels are typically between 50 to 80 percent of a grower's annual production history (APH) increasing at five percent increments (i.e. coverage levels of 50%, 55%, 60%, 65%,...,80%). Multiple forms of agricultural insurance schemes exist such as livestock and hail damage insurance. However, of particular interest is multi-peril crop insurance. This type of insurance protects the grower from yield losses that result from the many exogenous factors faced in agricultural production including natural disasters and pest damage. Typically, insurance schemes rely on risk-pooling where risks are not highly correlated among individuals and thus the total portfolio of the insurance company is less risky than the average of the individual policies. However, natural disasters are often correlated across a geographical area; thus pooling risk in this instance can be difficult for private insurers. Therefore, it is often the case that governments will handle multi-peril crop insurance coverage by subsidizing the premiums of the growers to ensure that indemnity payouts exceed the premiums paid by growers and that the operation costs of private insurers are covered (ERS, 1999). Premiums for growers are often subsidized up to 67% of the premium rate, which makes crop yield insurance particularly attractive to growers as a strategy to manage production risks.

Savings Groups: Savings groups are a management tool to mitigate financial risk. These groups are often structured as community-managed microfinance institutions where all fund accumulation is through member savings. Savings groups are often low-cost and easy to manage. They also allow members to build financial capital that can provide access to financial services from more formal institutions. Savings groups throughout the developing world allow members to have

access to savings accounts that are not typically available in rural communities. Also, savings groups do not have prohibitive barriers to credit access such as high collateral. These groups also allow members to access small loans which are often used to support agricultural businesses and often include emergency insurance for members (Ksoll, 2016; LeGrand, 2018).

Producer Groups: Producer groups or cooperatives, can be leveraged by growers to manage price and market risks. Producer groups give smallholder producers bargaining power to reduce agricultural input costs such as equipment, fertilizer, and seeds (FAO, 2007). Producer groups also lower marketing risk by creating improved access to markets through storage, delivery, packaging, and branding. Producer groups can also leverage negotiating power for selling goods at contract and market prices. Producer groups also play an important role in information sharing, education, technology, and training opportunities for producers (Feyisa, 2016).

Formal Credit Institutions: Formal credit institutions can assist farmers in managing financial risks. These institutions provide financial services in the form of small loans or insurance that allow smallholder producers to invest in more profitable farm business ventures. However, the use of formal credit institutions can be limited by high transaction costs, which are all the costs associated with conducting a business transaction such as travel time, financial literacy, and high collateral costs should farmers default on their loans. Collateral for loans is often in the form of land as it is one of the few production assets farmers possess (Agricultural Risk Management and Insurance, 2018).

METHODOLOGY

In this section, we describe the development of our questionnaire design, testing, and administration in order to accurately assess perceptions of risk and risk management strategies.

Risk and Risk Management Questionnaire Design and Administration

This study was conducted using a risk and risk management questionnaire collecting 1) demographic information about farm family and property attributes, 2) historical yields and prices for vegetable crops, 3) perceptions of risks in agriculture, 4) perceptions of risk-taking ability, 5) use and attitudinal assessments of eleven risk management strategies, and 6) access to risk management information and education. The questionnaire gathered data on basic demographic information to understand the sample population in the area. The questionnaire captured information on all vegetable crops grown in the last year and recorded up to five of the most recent yields and prices received for each crop. It also asked about crop failures including dates and causes. We needed to collect this information in order to construct a dataset with which to predict future yields and prices. Historical data for vegetable crops in Cambodia is nearly nonexistent.

We followed similar surveys in the existing literature (e.g, Koble et al., 1999; Meuwissen et al., 2001; Martin et al., 1998) when constructing the risk and risk management sections. Questions were contextualized for vegetable production as well as available marketing and financial options in Cambodia. The survey also captured farmer's willingness to take risks. Typically, the literature suggests using a likert scale (1-5). However, to accommodate for cultural perceptions observed

when this scale was pre-tested, we determined that a larger scale could create more accurate distributions and tease out risk-taking ability and important risks faced by growers in this region more accurately. Risk-taking in production, marketing, finance and investment as well as general risk-taking ability were assessed on a scale from 0-10 (0=Not Risk Seeking At All and 10=Very Risk Seeking). A similar scale was used by Meuwissen et al. (2001) and Dohmen et al. (2011). The scale used in this study most closely follows Dohmen et al. who study responses toward risks and risk-taking ability on attitudinal scales and compared the outcomes with behavioral experiments to determine the usefulness of attitudinal scales in self assessments of risk. They argue that self-assessments of risk-taking abilities are accurately captured in comparison to behavioral experiments (Dohmen et al. 2011). For consistency, we applied this scale throughout the entire questionnaire.

The questionnaire assessed the importance of 20 sources of risk including an open ended section for growers to include additional risk sources. Use and attitudes toward 11 different risk management strategies as identified in the literature above were also included. In addition, an open ended section was included to capture strategies not listed in the survey. Attitudes toward risk management strategies assessed included 1) awareness of strategy 2) interest in using strategy 3) comfort in using strategy 4) perceived benefit to income of strategy 5) perceived risk to income of strategy. Finally, if growers did not participate in a particular strategy, they were asked to specify why. Pre-coded response options were given to growers, as well as an open ended option allowing them to state alternative reasons why a particular strategy was not being adopted. Participants who engaged in alternative risk management strategies were asked questions that allow us to estimate costs and benefits of employing these strategies. Finally, respondents were also asked to rank 16 sources of risk management information and education on a scale of 0-10. The results of this section will be used in order to determine the appropriate channels in terms of outreach, cost, and accessibility in order deliver information on risk management strategies to growers in the future. The complete survey can be found in Kiely et al. (2019).

We tested the validity of the questionnaire through three forms of content validity. First, the literature review was used to justify the content and design sections relevant to our research objective. A draft questionnaire was then examined by members of the SVVC project in order to determine the appropriateness of questions given the current state of the Cambodian vegetable sector and those who operate within. Finally, we piloted the questionnaire in Kandal Province with 10 vegetable growers and we analyzed the instrument and questionnaire responses for conceptual understanding and feasibility. Adjustment was made to the survey instrument to reflect this. Finally, the questionnaire was administered to five farmers in Battambang Province to assess adjustments to the instrument. After completion of these initial surveys, it was determined that the questionnaire had obtained sufficient content validity and was used throughout the remainder of the fieldwork. Thirty vegetable growers were selected as respondents for the questionnaire. Fifteen growers were selected from both Tarsey and Anlongrun villages. The questionnaire was filled out during face-to-face interviews with the growers and the primary researcher and an interpreter, near the city of Battambang, Cambodia in the fall of 2017. All respondents had been growing vegetables for sale in local markets for a minimum of one year.

RESULTS & DISCUSSION

Household Demographics

To gain insight into the risk-taking ability and agricultural risks faced by Cambodian growers, as well as the importance of specific risk management strategies in context, we surveyed 30 smallholder farmers in two villages in Battambang province. Household demographics are shown in Table 1. The gender and age distribution as well as the family size between the villages surveyed were similar. Approximately 67% of the respondents were male, 33% were female and the average age of respondents was 43.5 years old. The average family size was 5.1 members. The land size and area under vegetable cultivation differed between villages. Farmers in Tarsey Village owned on average 1.36 hectares of land, while farmers in Anlongrun Village owned on average 2.47 hectares of land. The average area under vegetable cultivation on each farm surveyed in Tarsey Village was 0.25 hectares, while in Anlongrun Village it was 0.41 hectares.

Household Demographics			
Variable	Tarsey Village	Anlongrun Village	Mean of total survey respondents (n=30)
Age	43.8	43.2	43.5
Respondent Gender (M%:F%)	67:33	67:33	67/33
# Household Members	5.2	5.1	5.1
# Household Members Working on Farm Full-time	1.9	2.6	2.3
# of Children in Household	2.6	2.7	2.6
Male Head of Household Age	45.9	45.0	45.4
Male Head of Household Education (%)^a	0/47/47/7/0	13/73/13/0/0	7/60/30/3/0
Female Head of Household Age	44.3	41.5	42.9
Female Head of Household Education (%)^a	27/27/20/13/7	27/67/7/0/0	27/50/13/7/3
Land area owned (ha)	1.36	2.47	3.4
Area under cultivation (ha)	0.54	1.52	1.03
Area under Vegetable Cultivation (ha)	0.25	0.41	0.48

^a none/primary/secondary/high school/technical

Table 1. Household Demographics. Survey of 15 farming families in Tarsey Village and 15 farming families in Anlongrun Village

Income sources of farm families are displayed in Table 2. Despite the differences in cultivation area as exhibited in Table 1, growers in Tarsey village only generate \$621 less per year in vegetable production than growers in Anlongrun. This may be due in part to a focus on leafy green vegetable production in Tarsey which requires few infrastructure inputs compared to vegetables such as cucumbers, grown on stakes and wires, often in Anlongrun. Additionally, leafy green vegetables can be harvested more frequently throughout the year. Growers in Tarsey also benefit due to their

close proximity to the main road in the vicinity which may allow buyers to easily find these growers and lower buyer transaction costs. Income from aquaculture and personal business activities also vary between the two villages. Growers in Tarsey village almost solely relied on a water supply from a pond dug on their property which also provides an opportunity for aquaculture. Whereas, those in Anlongrun mainly sourced their water from a canal that meandered along the village, not allowing for the same income opportunity. Personal business activity is also likely a greater source of income for those in Tarsey village due to proximity the main road as households often had roadside shops selling snacks, household supplies, gasoline, or offering services such as auto repairs.

Household Income Source	Tarsey Village	Anlongrun Village	Mean income of respondents (n=30)
Vegetable Production	2,151	2,773	2,462
Non-vegetable Cropping Activities	2,325	1,886	2,106
Perennial plantation crops	267	-	133
Birds	-	10	5
Cattle, Buffalo, Pigs	17	120	68
Aquaculture	131	-	65
Jobs outside HH farm	228	271	250
Personal business activity	480	15	248
Public transfer	34	-	17
Total Household Income	5,641	5,135	5,388

Table 2. Household Income Sources. Income sources (USD) of 15 farming families in Tarsey Village and 15 farming families in Anlongrun Village

Perceptions of Sources of Risk and Risk-Taking Ability

Understanding farmers' perceptions of risk allows us to identify risk-aversion levels and suggest the most appropriate management strategies. Farmers' perceptions of risk-taking ability were categorized by the different facets inherent in agricultural activities: crop production, marketing of crops, and finance and investment, in addition to a category capturing general risk-taking ability. In a series of four questions, respondents were asked to rate on a scale of 0 to 10 how willing they are to take risks in the aforementioned categories (Fig. 1). All respondent's answers were then averaged to determine the average score of self-perceived risk-taking ability as shown here.

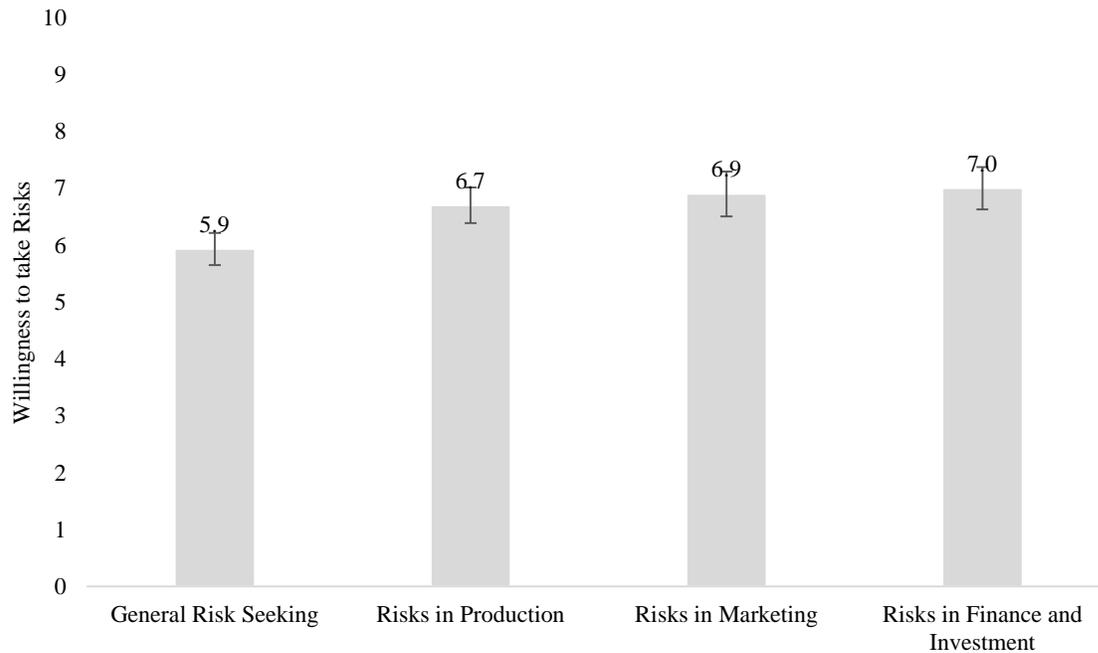


Figure 1. Self-Perceived Risk-Taking Ability. Average scored response of vegetable growers pertaining to risk-taking ability in agriculture as determined by four questions ascertaining degrees of risk-taking (where 0=Not Risk-Seeking at All and 10=Very Risk-Seeking).

The highest average score, representing the greatest level of risk-taking ability, was risk-taking in finance and investment. The lowest average score, representing the lowest level of risk-taking ability, was general willingness to take risks. This is interesting since it would be expected that general risk-taking ability would fall somewhere near the average of the three other categories. It is possible the three specific categories scored higher because they are areas in which respondents are well versed and have a good understanding of the relevant risks. This may likely explain why the scores for production and marketing are higher than general risk-seeking. However, since it is generally assumed that financial literacy is low among the rural poor, it might be expected that rural farmers would be most adverse to financial and investment risks. Therefore, it is surprising to see that growers responded to being most open to taking risks in finance and investment as they are likely to have less familiarity and exposure to the associated risks. Furthermore, despite the substantial difference in farm size and income between respondents in the two villages, no notable difference was identified in the perceptions of farmers towards risk. This suggests farmer perceptions towards risk are not dependent on farm size or income. Although the scope of this pilot study is limited, it is interesting to consider the idea that risk perception may be similar among the general population of Cambodian farmers.

Growers in Cambodia face risks on several fronts. Therefore it was important to capture potential risks faced and the degree to which these risks are a concern to growers. Realizing the most critical risk sources will enhance our ability to recommend applicable strategies to mitigate these risks. Assessing discontinuities between areas of risk-taking ability and actual risks faced is another important reason why this information is important to gather. If a misalignment of risk-taking

ability and risks exists, then management and training practices will be of even greater importance to bring awareness and action in alleviating these risks. Twenty sources of risk were considered in the questionnaire in order to ascertain the most burdensome risks growers encounter. Respondents were asked to score their perception of these twenty sources of risk on a scale of 0 to 10 in terms of their potential to affect farm income. Scores from all respondents were averaged and reported in categories grouped by related source of risk: price, production, financial, marketing, and personal risks (Fig. 2).

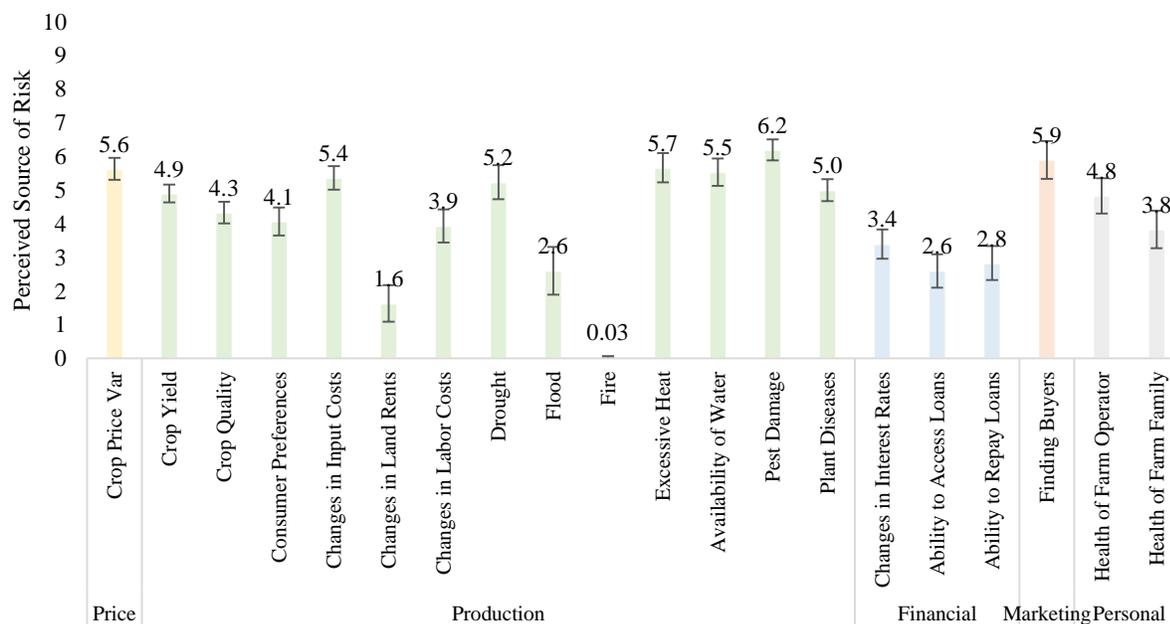


Figure 2. Perceived Sources of Risk to Vegetable Farming. Average scored response for perceived sources of risk in agriculture by 30 vegetable growers as determined by the 20 listed sources of risk rated in terms of their potential to affect farm income (where 0=Low Potential Effect on Farm Income and 10=High Potential Effect on Farm Income).

Sources of risk that received an average score of 5 or above with the inclusion of their standard error were considered highly relevant risks and those falling below five were considered irrelevant. Farmers perceived the most relevant sources of risk to be pest damage (score 6.2) and finding a buyer (score 5.9). These results are consistent with findings from other investigations (LeGrand et al. 2018). Other relevant sources of risks included: excessive heat (score 5.7), crop price variability (score 5.6), availability of water (score 5.5), and changes in input costs (score 5.4). These risks mainly pertain to extreme weather events likely to worsen in Cambodia as climate change brings higher temperatures to the area for longer periods of time as well as exogenous prices the growers cannot affect as price-takers. Finally, other relevant sources of risk include: drought (score 5.2), plant diseases (score 5.0), crop yield (score 4.9), and health of farm operator (score 4.8). It is interesting to note that crop yield as a risk source is lower than many of the sources that directly cause crop loss. The remaining 11 risk sources were deemed irrelevant. Interestingly, it seems that financial sources of risk were viewed as irrelevant, potentially due to the inability of producers to access financial resources. Whereas, growers stated they would be

most willing to take risks associated with finance and investment. Perhaps growers are more willing to take risks in this area as the available set of financial risks are likely to significantly alter income levels. From these results, it seems that the highest scoring sources of risk center around frequently faced exogenous factors associated with both production and marketing such as weather, pests, price volatility, and transaction costs. Understanding these results will help to inform the appropriate risk management strategies to incorporate.

Risk Management Strategies

Eleven risk management strategies were evaluated based on their ability to mitigate risk exposure faced by farm families. In the following sections, we analyze these risk management strategies based on their existing usage, growers' awareness and attitudes toward the strategies, and growers' perceived benefits and risks toward farm income through strategy incorporation.

Current Engagement with Risk Management Strategies

This section details the current usage of each risk management strategy. It is important to understand what strategies are currently being leveraged and their availability to growers. Additionally, we seek to identify if growers rely heavily on traditional risk management strategies or if there is local institutional capacity for alternative risk management strategies. Respondents were asked to state whether or not they currently engage in each of 11 risk management strategies. Figure 3 below displays the current use of these strategies.

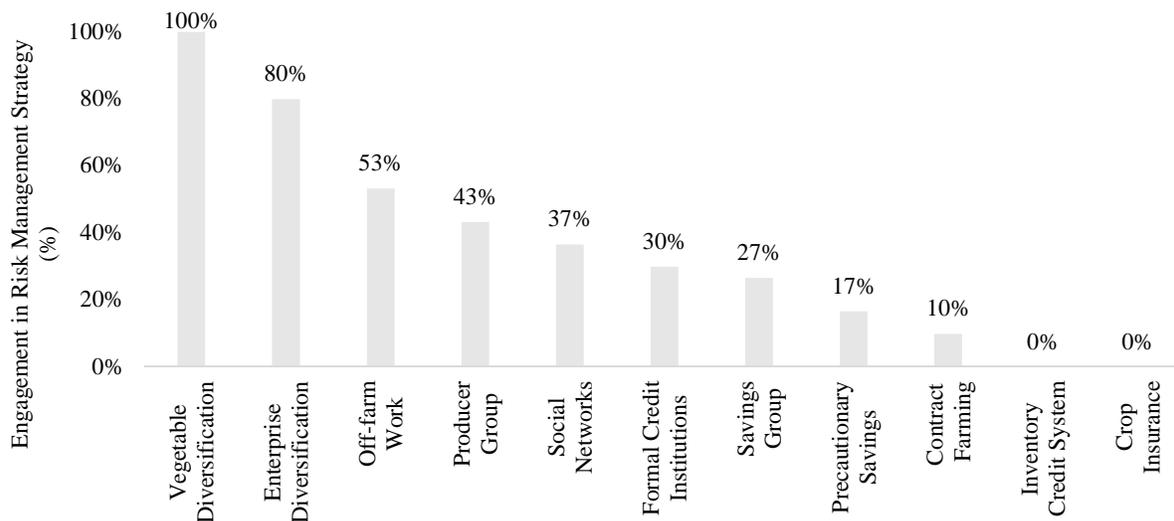


Figure 3. Current Engagement of Vegetable Growers with 11 Risk Management Strategies. Percent of vegetable growers currently engaged in each of 11 selected risk management strategies as determined by one yes/no question in questionnaire

All respondents were pre-selected on the basis of vegetable production and therefore it comes as no surprise that 100% of respondents grow a diverse set of vegetables as vegetables can be highly seasonable, forcing growers to plant different varieties to provide year-round income. Enterprise diversification has also been adopted by 80% of respondents. Enterprise diversification mainly came in the form of rice production or the raising of poultry, fish, or ruminants both for income

and family consumption. Respondents had moderate engagement with the traditional risk management strategies of off-farm work, and social networks, while having low engagement in precautionary savings. Respondents listed lack of access to savings and capital or an inability to repay loans as the primary reason for not engaging in these strategies. In terms of alternative risk management strategies, respondents had moderate engagement in producer groups and formal credit institutions, and low engagement in savings groups and contract farming. Respondents primarily stated that these alternative strategies were unavailable to them and secondarily stated unawareness of these strategies. The use of inventory credit systems and crop insurance is nonexistent as these risk management tools are currently unavailable to growers. While many of the alternative risk management strategies currently have low engagement rates, attitudinal assessments should be conducted to determine if usage rates would change if these strategies were made available.

Attitudes towards Risk Management Strategies

We seek to understand the attitudinal assessments of risk management strategies by growers to allow insights into their current awareness and receptiveness of these strategies. If levels of awareness are low while interest and comfort in using the strategy are high, farmer trainings can be leveraged in order to facilitate understanding of the strategy. Additionally, it would be evident that those receptive to adoption while displaying low levels of awareness may be more likely to adopt the strategy if it is made aware and available to growers. Respondents' average attitudinal assessments of risk management strategies are displayed below in Figure 4. In terms of awareness of strategies, results are grouped into clusters of high, moderate, and low levels of awareness. The high awareness cluster includes vegetable diversification and enterprise diversification which received average scores of 6.1 and 5.6 respectively. As these strategies had the highest levels of engagement it is not surprising to see this result. The moderate awareness cluster ranged from 3.5-4.5 and includes the traditional risk management strategies of off-farm work, precautionary savings, and social networks. The moderate awareness cluster also included the alternative risk management strategies of contract farming, savings groups, and producer groups. The low awareness cluster ranged from 1-3 and includes the alternative strategies of formal credit institutions, crop insurance, and inventory credit systems. It is not surprising to see formal credit institutions in the low awareness cluster as its use is rather low and it is viewed as the riskiest strategy. Crop insurance and inventory credit systems likewise are not offered at all which also explains their low awareness. It is surprising that savings groups and precautionary savings were in the low awareness cluster. It is likely that survey respondents did not have access to financial tools such as savings accounts and indeed it seems that growers rarely have savings in the first place. However, the idea of setting some money aside for hard times does not appear to be something they actively engage in. Savings groups had a rather low level of use according to survey respondents but it is surprising to see the level of unawareness of this strategy. Several growers responded that they did not belong to a savings group but knew that groups existed nearby.

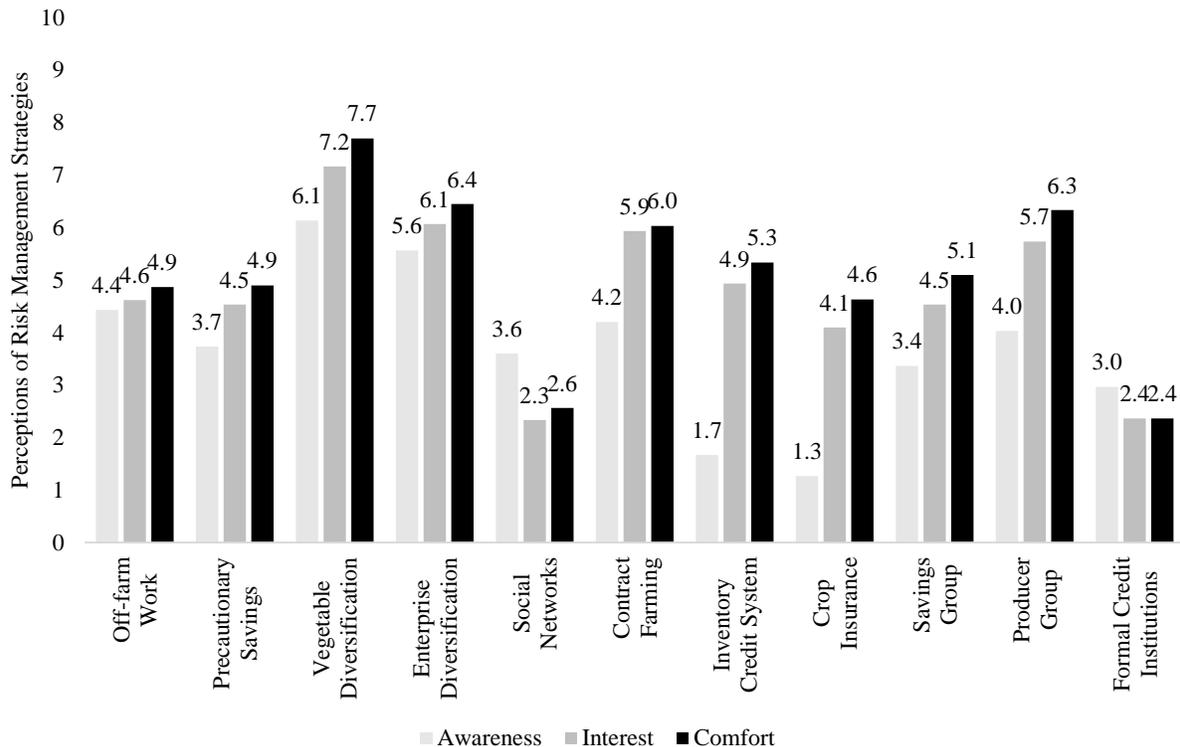


Figure 4. Attitudes toward Risk Management Strategies. Awareness, interest, and comfort of engaging in risk management strategies as determined by questionnaire were scored (where 0=Not Aware/Interested/Comfortable At All and 10=Very Aware/Interested/Comfortable) and averaged.

Interest in risk management strategies can again be grouped into high, moderate, and low interest clusters. The high interest cluster ranges from 6.5-7.5 and includes the traditional strategies of vegetable diversification and enterprise diversification as well as the alternative strategies of contract farming and producer groups. High interest levels in contract farming and producer groups are unsurprising as they are actively being implemented in these communities. The moderate interest cluster ranges from 4.0-5.0 including the traditional strategies of off-farm work, precautionary savings and the alternative strategies of inventory credit systems, crop insurance, and savings groups. Inventory credit systems and crop insurance both exhibit the highest difference in awareness and interest (3.2 and 2.8 respectively) suggesting these strategies may have high adoption rates if implemented. Finally, the low interest cluster ranges from 2.0-2.5 and includes social networks and formal credit institutions suggesting to an adverseness to loans and indebtedness.

Perceived comfort follows a very similar pattern with interest in risk management strategies. The high comfort cluster ranges from 6.0-8.0 and includes vegetable diversification, enterprise diversification, producer groups, and contract farming. Vegetable and enterprise diversification have the highest levels of engagement so it is unsurprising to see that growers are comfortable in using them. Producer groups and contract farming are the two alternative strategies that have been presented to farmers with active implementation. The middle comfort cluster ranges from 3.0-5.5

and includes inventory credit systems, savings groups, off-farm work, precautionary savings, and crop insurance. Again the difference between awareness and comfort in inventory credit systems and crop insurance are larger than any other strategy, suggesting high adoption if these strategies are made available to growers. The low comfort cluster ranges from 2-3 and is made of up of social networks and financial credit institutions, just as in the interest category.

Perceived Benefits and Risks

To shed light on the strategies growers may be likely to adopt, questions were asked about the perceived benefits and risks to income of incorporating these 11 risk management strategies. The average perceived benefits and risks to income of engaging in each of the 11 selected risk management strategies were rated by respondents from 0 to 10 and averaged (Fig. 5). The average perceived benefit score (light grey bars) was then compared to the average perceived risk score (dark grey bars) to determine whether farmers perceived each risk management strategy as an overall net benefit (green bars) or net risk (red bars).

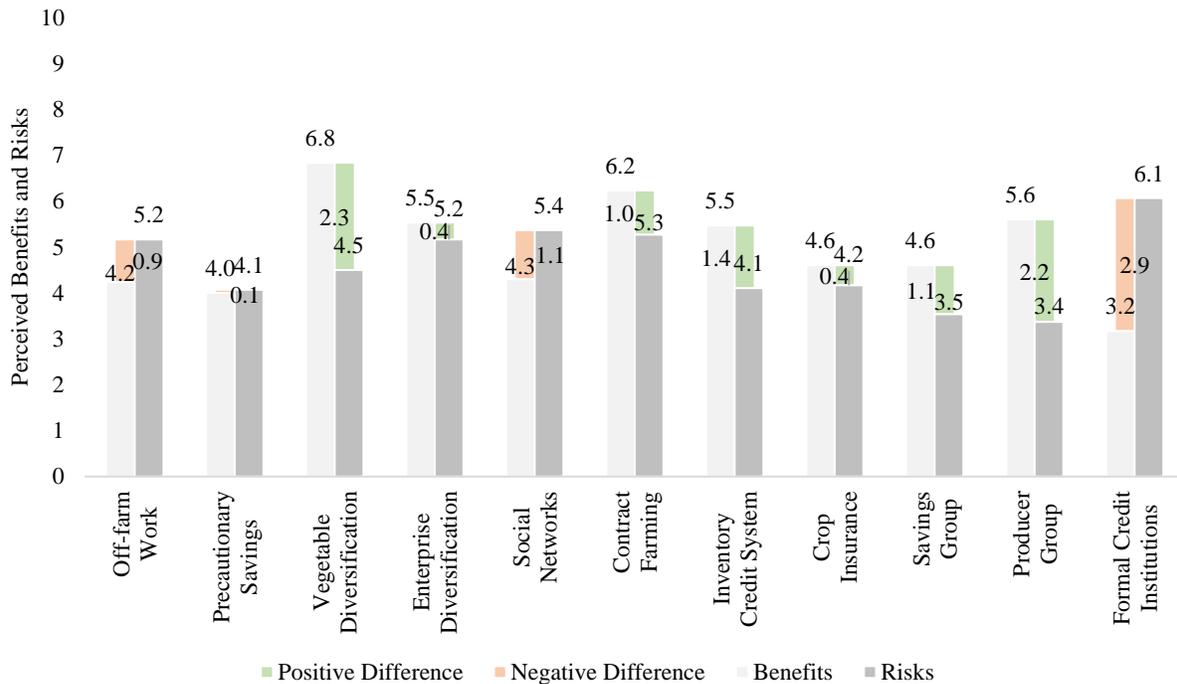


Figure 5. Perceived Benefits and Risks of Risk Management Strategies. Average scored response of perceived benefits (light gray) and risks (dark gray) of risk management strategies as determined by two scored responses ranging from 0-10 from questionnaire. A negative difference (red) indicates perceived risk is higher than perceived benefit, while a positive difference (green) indicates perceived benefit is higher than perceived risk (where 0=Not Beneficial or Risky At All and 10=Very Beneficial or Risky).

Three traditional risk management strategies, off-farm work, precautionary savings, and social networks, had average perceived risk scores which outweighed their perceived benefits. Of the strategies where average benefits had higher scores than average risks, the traditional strategies included vegetable diversification (+2.3) and enterprise diversification (+0.4). Vegetable

diversification also had the highest positive difference between benefits and risks. All alternative risk management strategies had higher average benefit scores than risk scores with the exception of formal credit institutions. Of the alternative risk management strategies, contract farming received the highest score in terms of perceived benefits to income (6.2) while producer groups had the highest difference between benefits and risks (+2.2) as well as the lowest perceived risks (3.4). It is interesting to note that growers seem more receptive to the alternative strategies. Perhaps their experience taught them that some traditional strategies do not significantly increase household income and they are willing to consider alternative strategies. The exception here is vegetable diversification. Vegetables are a cash crops with low inputs costs. Selection bias is also a likely issue with the high positive difference in vegetable diversification. Growers that did not see the benefits of this strategy would have stopped growing vegetables and would thus not be included in this survey. The high negative difference between formal credit institutions (-2.9) is misaligned with growers earlier statements that they are willing to take risks in the area of finance and investment.

Specific Recommendations

These assessments of use, awareness, and attitudes towards traditional and alternative risk management strategies allow us to make recommendations regarding alternative strategies. In order to address the most relevant risks identified by growers, strategies that focus on 1) securing buyers, 2) market prices, 3) addressing costs of inputs and 4) minimizing crop damages due to natural events should be prioritized. To address the costs of agricultural inputs, we recommend the promotion and formation of both producer and savings groups. Producer groups provide growers with bargaining power to lower the costs of inputs while savings groups afford growers the opportunity to access small loans and savings, granting growers with the cash endowments to secure expensive agricultural equipment including tillers and water pumps.

The two alternative market strategies available to address securing buyers and market prices are contract farming and inventory credit systems. We recommend contract farming to be used in favor of inventory credit systems as contract farming continuously secures a buyer whereas an inventory credit system simply lengthens the time available to find a buyer and can increase transaction costs of operation. Contract farming also stabilizes the prices received by growers reducing uncertainty of income and allowing for better future planning and investment. While inventory credit systems can allow growers to capture spikes in market prices that exceed contract prices, the uncertainty of these prices places great risk on the part of the grower and it is possible that growers would find greater utility from stable prices rather than continually attempting to capture high market prices, not obtained with certainty. Perhaps most importantly, contract farming is likely to be a preferred strategy over an inventory credit system when it comes to horticultural products as the latter needs the appropriate cold chain technology in order to function properly as horticultural crops are highly perishable and cannot be stored indefinitely. Currently, cold chain technology in the post-harvest production process is limited in its use and availability in Cambodia. While the current SVVC project is working to introduce cold storage through coolbots, it does not seem like an inventory credit system is the optimal current pathway for growers. Once a more robust cold-chain storage system is in place piloting of an inventory credit system may be possible and growers not engaged in contract farming may be interested in participating in the study. Therefore, as contract farming has higher levels of current use, awareness, interest, comfort, and perceived benefits, as well as having the ability to be

implemented in the near future, contract farming will be the alternative marketing risk management strategy recommended for implementation.

Finally, growers indicate that the exogenous factors related to natural events such as extreme weather conditions and pests are some of the biggest risks faced. While this particular study does not focus on tangible agricultural risk management strategies that can negate the yield losses from these events, the introduction of crop insurance is a potentially viable method to introduce to growers. Crop insurance can be an income smoothing strategy when crop losses reach a certain threshold and thus is the main alternative risk management strategy considered in this research to mitigate production risks. Therefore, crop insurance is the recommended intangible risk management strategy recommended to alleviate production risks faced by growers as its perceived benefits outweigh the risks and growers are moderately interested and comfortable in accessing it.

Producer and Savings Groups

Changes in the costs of agricultural inputs can be addressed through the formation of producer groups. This alternative risk management strategy can allow a collective of farmers to obtain bargaining power, enabling them to receive bulk pricing discounts on input supplies. Additionally, a producer group can have the added benefit of ensuring that the procured input supplies are of high quality, a major issue growers struggle with in Cambodia. Indeed, the SVVC project has just begun to form a producer group “Tasey Smaki Agricultural Cooperative” (TSAC). This recently formed group no doubt influenced survey results of use of and attitudes toward producer groups. However, as a producer group addresses some of the major risks identified by farmers including input costs and the marketing and labeling of produce, in addition to the benefits of information-sharing, producer groups remain a highly recommended alternative risk management strategy. As TSAC has only recently been formed, it is unclear at this time what growers ultimately want the producer group to achieve. However, it is advised that in addition to bargaining to reduce input costs, the producer group be used to leverage negotiations of contract farming output prices and serve as a platform for technology and information sharing, grower training workshops, and the introduction and development of savings groups.

Savings groups offer an alternative method of financial and capital access to smallholder growers incapable of accessing traditional lending institutions. It is encouraged that growers belonging to TSAC be given the opportunity to opt-in to the savings group with access to a savings account earning an agreed upon interest rate as well as the opportunity to secure small loans which can, for example, be used to purchase expensive inputs such as tillers, tractors, or irrigation supplies that may otherwise not be accessible. It is suggested that growers consider organizing the savings group as a “shared interest savings group” (SISG). In addition to accessing savings and small loans, a SISG is comprised of members with common interests across the agricultural supply chain. The SISG allows for open dialogue to identify agricultural and supply chain issue, test solutions, and apply early scaling of agricultural technologies (LeGrand, 2018). As the savings group falls under the umbrella of the producer group, the “shared interest” component of the savings group should not be difficult to develop. Membership to the SISG should, however, not be limited to producer group members. Other community members should be encouraged to join and engage in participatory learning and information-sharing to promote food safety practices, technology adoption, market access, and financial access and inclusion.

Contract Farming and Crop Insurance

The results of this study suggest the implementation of contract farming and crop insurance would alleviate some of the greatest risks faced by growers. Additionally, these growers already seem highly receptive to implementing these risk management strategies. Contract farming, through the production of pesticide-free vegetables, as displayed in the Horticultural Innovation Lab model, would alleviate pest damage, the pressure of securing a buyer, and crop price variability, three of the greatest concerns expressed in the questionnaire. While crop insurance cannot directly stabilize crop price variability, pest damage, or excessive heat, it can act as an income-smoothing strategy to mitigate the impacts of production risks and also has the potential to buffer income when market prices fall. Thus this management strategy also mitigates major production risks. Although these strategies may address many production risks, adoption of technologies, techniques, and practices is often difficult to overcome. However, farmers seem to respond favorably to these two risk management strategies presently. As seen in Figure 5, on average, farmers weighed the benefits of contract farming and crop insurance greater than the risks of incorporating these strategies. Additionally, farmers displayed high levels of interest and confidence in utilizing contract farming (Figure 4) while also exhibiting fairly high levels of interest and confidence in employing crop insurance despite having lower levels of awareness of this strategy than any other strategy. Therefore, it appears likely that high demand would exist for these opportunities if offered. However, these two strategies represent two of the three lowest levels of engagement of the risk management strategies surveyed. It seems evident that creating programs focused on the implementation of crop insurance and contract farming is low-hanging fruit for the Cambodian government and development organizations operating in the country.

It is likely that the introduction of crop insurance will have to be implemented by the Cambodian government. At the very least, private companies must be backed by the government in order to make crop insurance successful as the covariate risks associated with farming often make it infeasible for private companies to generate a profit. Additionally, information asymmetries such as adverse selection and moral hazard make it difficult for private insurance companies to exist within agriculture. Therefore, it is suggested that crop insurance be backed by the government and subsidized so as to be affordable for growers. If the government of Cambodia is serious about meeting domestic vegetable demand and alleviating poverty amongst its citizens, the impact of crop insurance cannot be denied.

The implementation of contract farming will lead to increased uptake in recordkeeping of crop yields. This may pave the way for the establishment of long-term, well-structured crop insurance that relies on a history of crop yields in order to effectively determine significant yield losses. Often, the yield history at each farm is used, however, area wide yields can also be used. By collecting extensive data from these farmers, area-wide yields can be determined, thus paving the way for crop insurance. Additionally, as vegetable farmers often produce many vegetable types, insurance programs may find that crop insurance is impractical in its ability to cover all types of vegetables. However, bundling many vegetables grown in this area under “leafy greens” or under the brassicaceae family will help to eliminate this issue. Additionally, using adjusted gross revenue insurance (AGR) would eliminate this impracticality by focusing instead on revenue as opposed to crop-by-crop yields. In order to facilitate greater demand and eventual adoption of these strategies, financial literacy workshops need to be established to familiarize growers with these concepts and display the benefits these tools offer. Based, on the questionnaire results, it

seems that growers prefer workshops organized by universities and NGOs which should both be leveraged to accomplish this goal.

4.4.3 Training and Education to Support the Implementation of Risk Management Strategies

Risk management strategies also need a platform in which training and education can be disseminated to growers. To help determine the types of information dissemination strategies with the most potential to meet the needs of vegetable growers, we asked growers a series of questions to determine their preferences for training and education (Fig. 6).

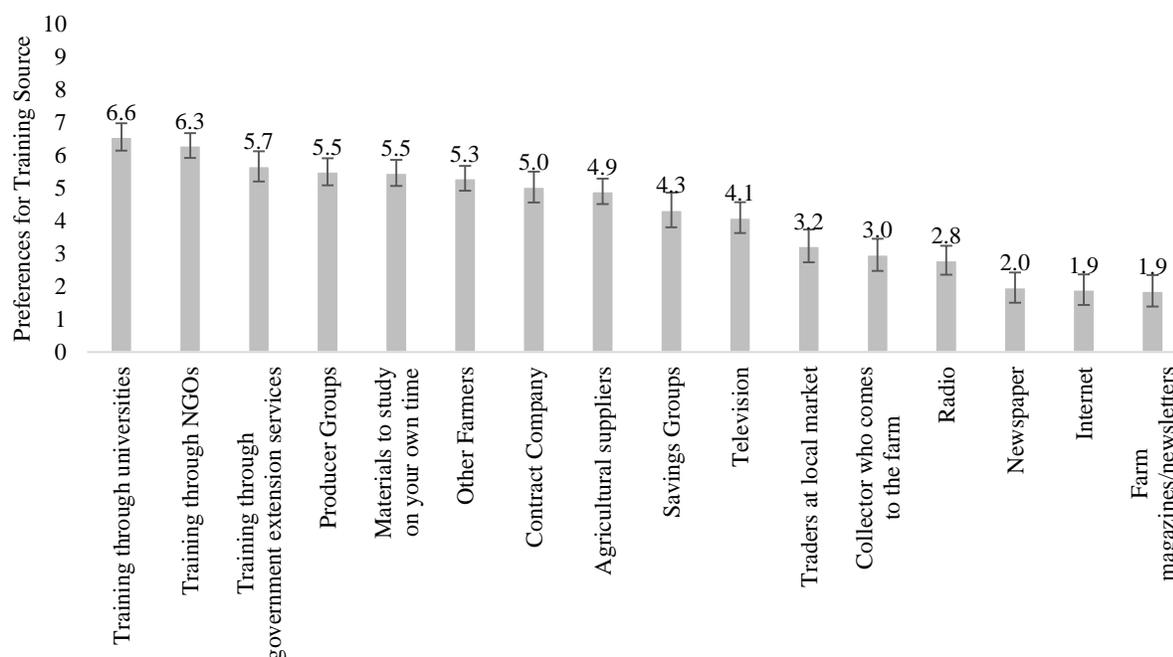


Figure 6. Producer Preferences for Training and Education. Average Scored Response for 16 Preferred Sources of Training and Education on Risk Management Strategies as Determined by Scored Responses from the Questionnaire (where 0=Low Preference and 10=High Preference)

Farmers reported the highest preference for training and education would be through universities and NGOs (average scores 6.6 and 6.3, respectively). The moderate preference cluster ranged from 4.0-6.0 and includes training through government extension agencies, producer groups, self-learning, other farmers, contract companies, agricultural suppliers, savings groups, and television. The low preference cluster ranged from 2.0-4.0 and includes local traders, collectors, radio, newspaper, internet, and farm magazine/newsletters. It is advisable that the recommended alternative risk management strategies be delivered through the established producer group by universities or NGOs specializing in educating growers on each of the respective strategies. The SVVC team and TSAC have established a “Safe Agriculture Learning Center” which can raise awareness of alternative risk management strategies that growers are unfamiliar with such as crop insurance. This platform may also raise interest, comfort, and perceived benefits in using these strategies while simultaneously lowering the perceived risks as growers receive more information and become more familiar with the strategies.

CONCLUSION

The existing vegetable sector in Cambodia is underdeveloped and poorly managed, and prone to be affected by exogenous shocks. To date, it fails to meet domestic consumer demand. Vegetables are typically imported from Vietnam and perceived not as safe as domestic vegetables despite similar production methods. The Cambodian government is trying to assist local growers to access more of the domestic market and take advantage of this perception and window of opportunity before production standards in neighboring countries improve and production costs decrease. However, Cambodian vegetable growers are exposed to exogenous production, market, and personal shocks that can greatly impact yields, prices, and incomes of these smallholder operations and it necessary to examine current and potential risk management strategies to properly safeguard vegetable growers and secure long-term economic self-sufficiency.

This study examined attitudes towards, knowledge and use of eleven traditional and alternative risk management strategies in order to determine which practices are under-utilized, have the potential for high rates of adoption, can increase grower income, and induce farmers into transitioning into vegetables production. We find the implementation of producer groups and savings groups will allow growers to decrease input costs, increase economies of scale, promote information-sharing and problem-solving, and offer greater financial savings and access. The employment of contract farming and crop insurance are low-hanging fruit in that they are used infrequently as few channels exist for farmers to assess these risk management strategies.

We also recommended that the government of Cambodia develops a crop insurance program that subsidizes insurance for growers and makes coverage affordable to farmers. Additionally, it is necessary to establish an environment that promotes business opportunities where producers and marketers can coordinate and streamline production of safe-vegetables. These directions will likely increase the use of contract farming, reduce production risks and positively impact vegetable growers. The Cambodian government can simultaneously achieve its goal of meeting domestic vegetable demand while increasing grower incomes and reducing poverty, and thus increase social welfare overall.

Future Research

Multiple directions of future research can be pursued as an extension of this study. Surveying additional growers could give greater insight into the accuracy of prices and per area yields in this study. It could extend the understanding regarding attitudes, knowledge and use of traditional and alternative risk management strategies and its underlying cost and benefit perceptions. Once the implementation and use of the cold storage facility is established for instance, producer groups in Battambang may want to pilot an inventory credit system. To the author's knowledge, there has been no attempt to link inventory credit systems to vegetables at this point and a pilot study may demonstrate the viability of linking vegetables with inventory credit systems to growers who are not engaged in contract farming in order to mitigate post-harvest losses or avoid low market prices.

References

- “Agricultural Risk Management and Insurance.” *Agricultural Finance and Opportunities for Investment and Expansion Advances in Finance, Accounting, and Economics*, pp. 221–234., doi:10.4018/978-1-5225-3059-6.ch012.
- Asian Development Bank (2014). Cambodia: Country Poverty Analysis 2014. Manila, Philippines.
- Bhattamishra, Ruchira, and Christopher B. Barrett. “Community-Based Risk Management Arrangements: An Overview and Implications for Social Fund Program Design.” *SSRN Electronic Journal*, 2008, doi:10.2139/ssrn.1141878.
- Coble, K.H., et al. (1999) “Crop Producer Risk Management Survey: A Preliminary Summary of Selected Data.” Presentations, Working Papers, and Gray Literature: Agricultural Economics. University of Nebraska-Lincoln.
- Dohmen, Thomas, et al. “Individual Risk Attitudes: Measurement, Determinants, And Behavioral Consequences.” *Journal of the European Economic Association*, vol. 9, no. 3, 2011, pp. 522–550., doi:10.1111/j.1542-4774.2011.01015.x.
- Drollette, Sarah A. *Managing Financial Risk in Agriculture*. Department of Applied Economics, 2009, *Managing Financial Risk in Agriculture*.
- Economic Research Service, United States Department of Agriculture. “Managing Risk in Farming: Concepts, Research, and Analysis”. USDS, 1999.
- Eliste, Paavo; Zorya, Sergiy. 2015. *Cambodian agriculture in transition : opportunities and risks (English)*. Washington, D.C. : World Bank Group.
- FAO (2007). Approaches to linking producers to markets. Rome, FAO.
- FAO (2014). Country Fact Sheet on Food and Agriculture Policy Trends. Rome, FAO.
- Feyisa, Ashenafi Duguma. “The Role of Agricultural Cooperatives in Risk Management and Impact on Farm Income: Evidence from Southern Ethiopia.” *International Journal of Economic Behavior and Organization*, vol. 4, no. 4, 2016, p. 28., doi:10.11648/j.ijebo.20160404.11.
- G. David Miller, Karen LeGrand, Fred Sagemuller, Cary Trexler, Glenn Young, Neda Yousefian. “Partnership in Agricultural Community Entrepreneurship (PACE).” (2017). *International Journal of Interdisciplinary Research and Innovations*. 5(3):1-8.
- Gunjal, Kisan. *Agricultural Risk Management Tools*. PARM, 2016.
- Hardaker, J. Brian, et al. *Coping with Risk in Agriculture*. CABI, 2007.
- Kiely, Sean, et al. “Case Study: Risk and Risk Management Strategies for Smallholder Vegetable Growers in Battambang, Cambodia.” 2019. University of California, Davis. Master’s Thesis.
- Kahan, Davis. *Managing Risk in Farming*. FAO, 2008, p. 8, *Managing Risk in Farming*.
- Ksoll, Christopher, et al. “Impact of Village Savings and Loan Associations: Evidence from a Cluster Randomized Trial.” *Journal of Development Economics*, vol. 120, 2016, pp. 70–85., doi:10.1016/j.jdeveco.2015.12.003.
- Kula, Turner, & Sar. *An Analysis of Three Commodity Value Chains in Cambodia Rice, Horticulture, and Aquaculture*. 2015, avwebmaster.wpengine.com/wp-content/uploads/sites/default/files/attach/2015/04/LEO-Cambodia-Value-Chain-Assessment.pdf.
- LeGrand, K., Yamashita, L., Trexler, C. J., An, V. T. L., & Young, G. M. (2017). Developing Food Science Core Competencies in Vietnam: The Role of Experience and Problem

- Solving in an Industry-Based Undergraduate Research Course. *Journal of Food Science Education*, **16**(4), 118-130.
- LeGrand, K., Buntong, B., Chuong, T., Miller, G. D., Kong, T., Trexler, C. J., & Young, G. M. (2018). Leveraging Shared Interests to Advance Sustainable Food Safety Systems in Cambodia. *Journal of Rural and Community Development*, **13**(3), 167-191.
- MARD, (2009). Safe vegetable production in Vietnam. Accessed 5 June, 2010 at: <http://www.agroviet.gov.vn/>
- Martin, S., and F. Mcleay. "The Diversity of Farmers' Risk Management Strategies in a Deregulated New Zealand Environment." *Journal of Agricultural Economics*, vol. 49, no. 2, 1998, pp. 218–233., doi:10.1111/j.1477-9552.1998.tb01265.x.
- Meuwissen, M.p.m., et al. "Sharing Risks in Agriculture; Principles and Empirical Results." *NJAS - Wageningen Journal of Life Sciences*, vol. 49, no. 4, 2001, pp. 343–356., doi:10.1016/s1573-5214(01)80022-1.
- Sophal, (2009). Interview with Huong Sophal, dean of the faculty of agronomy at the Royal University of Agriculture. Accessed online 30 Sept, 2010 at: <http://www.sea-globe.com/cambodia/89-economy/291-insearch-of-fertile-ground?tmpl=component&print=1&page=>
- Southeast Asia Globe. (10 Sept., 2009). In search of fertile ground. Accessed online 30 Sept, 2010 at: <http://www.sea-globe.com/cambodia/89-economy/291-in-search-of-fertileground?tmpl=component&print=1&page=>
- Trexler, Cary (2016). Building Safe Vegetable Value Chains through Social Science Research Collaborations in Cambodia. UC Davis Global Affairs, Seed Grant.
- Ullah, Raza, et al. "Managing Catastrophic Risks in Agriculture: Simultaneous Adoption of Diversification and Precautionary Savings." *International Journal of Disaster Risk Reduction*, vol. 12, June 2015, pp. 268–277., doi:10.1016/j.ijdr.2015.02.001.