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Effects of Risk Attitude and Risk Perceptions on Risk Management Decisions: Evidence from Farmers in an Emerging Economy

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Using primary survey data of onion growers in India, this study tests the relationship between and predictability of risk attitude measures on farmers' risk management decisions. We find that farmers with high risk aversion are more likely to adopt farm diversification strategies, good agricultural practices, government-recommended seed varieties, and preventive measures against diseases and pests than farmers with low risk aversion. The likelihood of farmers adopting good agricultural practices decreases with perceived higher risks of low-quality production, a higher risk of losing crops due to weather, and insects and pests.

Key words: enterprise, high-value crops, lottery, nonfarm income, quality-enhancing practices, risk preference

Introduction

Risk attitude is an individual's orientation toward risk-taking. Risk attitudes can vary, from high risk aversion (i.e., very unwilling to take risks) to low risk aversion, or risk lovers (i.e., very willing to take risks). Risk perceptions (or perceived risks) are the way in which an individual perceives or assesses risk. Different people have different attitudes toward risk, which causes them to deal differently with risky situations. Risk attitudes have also been shown to be context-specific (Slovic, Fischhoff, and Lichtenstein, 1982; Pennings and Garcia, 2001). Individual risk behavior, both in terms of risk attitude and risk perception, could guide an individual's risk management strategy. However, risk perception or risk attitude can have a differential impact on risk management decisions (van Winsen et al., 2016). Lusk and Coble (2005) suggest that optimal risk-taking behavior depends on both risk attitude and risk perception. Understanding of risk behavior both in terms of risk attitude and risk perception is important.

Although risk perception and risk attitude are independently described in the literature, little research describes the interaction between risk perception and risk attitude and how they guide risk behavior (van Winsen et al., 2016). Few studies have analyzed risk management questions collectively using both risk attitude and risk perception measures or their combinations. Farming, especially in developing and emerging economies, offers a case study to investigate risk behavior.

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Agriculture is increasingly confronted with risk and uncertainty arising from various sources such as production risk, price volatility, personal risks, and policy changes (Hardaker et al., 2015). In production agriculture, risks may include the perceived risk of climate and weather, disease-pest risk, productivity or quality degradation (Slovic, Fischhoff, and Lichtenstein, 1982; van Winsen et al., 2016; Rizwan et al., 2020). Farming decisions are primarily made by a single person who aims to maximize production and profit and sustain farming as an occupation.

A farmer's choice of risk management strategies is vital for the viability and continuation of a farming business. This is even more important for farmers producing high-value crops, which require relatively higher initial investment (e.g., seed, technology, and inputs) for smallholders in emerging economies like India. While farmers cope with risk and uncertainty in different ways, risk and risk attitudes are considered important drivers of on-farm risk management strategies, crop choice, and land-use decisions. Moreover, risk attitude has been recognized as an essential factor in the technology adoption decision-making process (Feder, Just, and Zilberman, 1985; Sitkin and Weingart, 1995; Cho and Lee, 2006). The decision-making process regarding risk management strategies and the role of risk attitude enhances the understanding of farmers' risk behavior, acreage allocation, yields, and technology adoption. Smallholders may not always understand that their choices are different from other smallholders due to differences in their risk perception (RP) and risk attitudes (RA) rather than being driven by external influences and structural barriers. Finally, policy makers, especially in emerging economies, need a better understanding of farmers' attitudes toward risk and choices of risk management strategies when designing policies to support production agriculture.

The objective of this study is twofold. First, using primary survey data from onion growers in India, we examine smallholders' risk behavior by assessing risk attitude and farmers' self-assessment of risk attitude. Second, we evaluate RA and RP measures' effect and predictive power on adopting risk management strategies and quality-enhancing production practices. To the best of our knowledge, no previous studies have examined these research questions in the context of high-value crop growers in India.

Conceptual Model

The basic notion behind adopting risk management strategies is that stable farming returns through overall revenue maximization or downward loss minimization. We assume that, as a rational decision maker, a farmer examines distributions and evaluates returns in choosing each risk management strategy. A farmer maximizes the expected utility of end-of-period total wealth; expected utility is assumed to be strictly increasing, concave, and twice continuously differentiable (Coble, Heifner, and Zuniga, 2000; Ke and Wang, 2002). The farmer can derive utility from monetary wealth and leisure, so we assume an objective function with two arguments. By choosing assets (e.g., land allocations and other assets that provide returns) and income-generating activities subject to diversification and adequate risk management, farmers can derive wealth. Following Bar-Shira, Just, and Zilberman (1997), we assume that a farmer is utility maximizing and represent the farmer's problem as

(1) $$\max_{A,T^l} E\left[U\left(W,T^l\right)\right] = \max_{A,T^l} E\left[U\left(W_0+\varphi' A, T^l\right)\right],$$

subject to

(2) $$\bar{T} - \sum_{j=1}^{j} T_j A_j = T^l,$$

(3) $$\sum_{j=1}^{j} A_j \leq \bar{A},$$

where A is a vector of assets (e.g., land and other assets) allocated to j different return-generating strategies on the farm and φ is a corresponding vector of returns; T represents dedicated time allocation (e.g., out of total time $\bar{T}, T^l$ is time for leisure and T_j is time for j element of the certain asset).[1] The first constraint (equation 2) represents the time constraint in such a way that time for leisure, T^l, should be equal to total available time minus time spent on farm activities (allocated time on different assets that generate returns on the farm). Equation (3) represents the second constraint: Total assets allocated cannot exceed total available assets. Partial differentiation with respect to assets and maximizing the objective function after substituting constraints provides the following first-order conditions:

$$\text{(4)} \qquad \frac{\partial E[U]}{\partial A} = E\left[\varphi . U_w\right] - E\left[T . U_{T^l}\right] = 0,$$

where U_w and U_{T^l} are partial derivatives with respect to wealth and leisure, respectively. Equation (4) can be interpreted as the trade-off on marginal utility from allocating to return-generating assets versus one more unit of leisure; in the absence of a labor market, the cost of labor can be determined by its opportunity cost in terms of leisure (Bar-Shira, Just, and Zilberman, 1997).

Risk is another critical factor affecting decision making. Behavior under uncertainty differs from behavior under certainty. Thus, farmers producing products under uncertainty may use crop diversification as a risk management tool. For instance, an individual profit-maximizing farmer might grow a particular crop under certain conditions. Under uncertainty, the same farmer might diversify and grow many crops (Bar-Shira, Just, and Zilberman, 1997; Khanal and Mishra, 2017).

We want to simplify and concentrate on the utility of the wealth component and risk management decisions, elaborating on assets A and returns φ discussed in equation (1), linking with asset returns. Consider a farm operator deciding whether to adopt any, some, or all the agricultural risk management strategies, k, available to him or her $(k = 1, \ldots, n)$. Note that risk management strategies incur some direct costs or costs that can be achieved by reducing total return, diversifying, and/or shifting capital to less profitable but safer activities to minimize variation in total return (Blank, 1990). Consider a farmer who assesses each of the risk management strategies about the return distribution to a set of assets, A, used in production, which have a stochastic rate of return, φ_A, with mean $\bar{\varphi}_A$ and variance σ_A^2, signifying overall operational risks. This study uses assets rather than wealth because asset allocation and asset returns are something that farmers directly examine and decide on the farm when it comes to risk management. With an inherent link between wealth and assets, the expression still conserves the expected utility maximization framework's primary intention on wealth and leisure:

$$\text{(5)} \qquad \bar{\varphi}_t = \bar{\varphi}_A(A),$$

$$\text{(6)} \qquad \sigma_t^2 = (A)^2 \sigma_A^2,$$

where $\bar{\varphi}_t$ is expected total rate of return and σ_t^2 is the variance of total returns. The maximized expected utility of end-of-period wealth, represented in terms of certainty equivalent, can be expressed as

$$\text{(7)} \qquad W_{CE} = \bar{W} - \rho \sigma_w^2,$$

where W_{CE} is the operator's certainty equivalent of end-of-period wealth, W, with mean $\bar{W}$ and variance σ_W^2, and ρ is a parameter of risk attitude or risk aversion. Depending on situations, total wealth could have fixed, stochastic part (income); a variable, nonstochastic part (initial wealth); or both stochastic and nonstochastic components of the wealth changing proportionally. The appropriateness of absolute or relative risk attitude (or aversion) is based on these two considerations

[1] For example, in land asset and crop choice decisions, T_j can be the cultivation time of crop j.

of stochastic and nonstochastic components of total wealth (Bar-Shira, Just, and Zilberman, 1997). Arrow (1965) shows that relative risk aversion, ρ, is given by

$$\rho = \frac{-U''(W)}{U'(W)} \cdot W, \tag{8}$$

where U'' and U' are the second- and first-order derivatives of the utility function, $U(.)$. The derivatives are assumed to be continuous and twice differentiable, consistent with the von Neumann–Morgenstern utility function. Even in the case of partial risk aversion, Bar-Shira, Just, and Zilberman (1997) show that the behaviors of the measure of absolute or relative risk aversion are sufficient to determine the extent of partial risk aversion. The concept of risk aversion suggests that for the same end-of-period wealth and output (W), a farmer with a utility function U_α is considered to be more risk averse than the one with utility function U_β if and only if $-\frac{U''_\alpha(W)}{U'_\alpha(W)} > -\frac{U''_\beta(W)}{U'_\beta(W)}$. The Arrow–Pratt measure of risk aversion is considered a robust measure of risk attitude because it is invariant under transformation (Hansson, 2018). Following the derivation shown in Velandia et al. (2009), W_{CE} correspondence on maximizing certainty-equivalent rate of return (φ_{CE}), expressed in terms of expected mean and variance, $\overline{\varphi_t}$ and σ_t^2, is

$$\varphi_{CE} = \bar{\varphi}_t - \rho\sigma_t^2. \tag{9}$$

Substituting the expression from equations (5) and (6) to equation (9) gives

$$\varphi_{CE} = \bar{\varphi}_A(A) - \rho(A)^2\sigma_A^2. \tag{10}$$

Changes in the mean and variance of the return distribution and incurred costs (C) associated with adopting each risk management decision define risk management strategies. Incorporating the cost (C_k), a farmer's realization of costs for each risk management strategy k in certainty equivalent framework can be expressed as

$$\varphi_{CE,k} = \bar{\varphi}_{A,k}(A) - C_k - \rho(A)^2\sigma_{A,k}^2. \tag{11}$$

For each risk management strategy k, the farmer has some threshold highest level of expenses willing to make, called reservation cost C_k^*. Reservation cost is essentially a point that makes a farmer's utility indifferent between before and after adopting that risk management strategy. Adapting Velandia et al. (2009) on deriving reservation cost, using equations (10) and (11) enables us to solve for C_k^*:

$$\bar{\varphi}_A(A) - \rho(A)^2\sigma_A^2 = \bar{\varphi}_{A,k}(A) - C_k - \rho(A)^2\sigma_{A,k}^2, \tag{12}$$

$$C_k^* = A\left(\bar{\varphi}_{A,k} - \bar{\varphi}_A\right) - \rho(A)^2\left(\sigma_{A,k}^2 - \sigma_A^2\right). \tag{13}$$

Using equation (13), a farmer decides to adopt a particular risk management strategy if the difference between the reservation cost and the actual cost is greater than 0 (i.e., if $C_k^d > 0$, $C_k^d = C_k^* - C_k^{actual}$). Note that the difference, C_k^d, is unobservable (latent) but the adoption decision, $\mathscr{Y}_k$, is observable, which in the discrete case can be expressed such that

$$\mathscr{Y}_k = \begin{cases} 1 \text{ if } C_k^d > 0 \\ 0 \text{ if } C_k^d \leq 0 \end{cases}, \tag{14}$$

where $\mathscr{Y}_k = 1$ if the farmer adopts risk management strategy k and $\mathscr{Y}_k = 0$ otherwise.

Equation (14) enables us to estimate the factors influencing risk management decisions. From equation (13), the variables related to asset size, risk attitude (preference) measure ρ, and variables contributing to mean and variance difference of return on assets are the main determinants of the reservation cost, which directly affects unobserved latent variable C_k^d and the decision to adopt a particular risk management strategy.

Table 1. Example of Risk Attitude/Preference Elicitation by Lottery Exercise Used

Risk Attitude Measure [RA1]	Risk Attitude Measure [RA2]
Risk preference elicitation approach: Hypothetical payoff matrix (Choose one option in every exercise) 1=If you choose A, you will get 30 Rs. 2=If head is achieved you'll get 40, otherwise 25 3=If head is achieved you'll get 50, otherwise 20 4=If head is achieved you'll get 60, otherwise 15 5=If head is achieved you'll get 70, otherwise 10 6=If head is achieved you'll get 80, otherwise 0	There are three types of lottery in first case if you win you will get 100 Rs otherwise you will get 100 Rs. In second case if you win you will get 200 Rs otherwise 50 Rs. In third case if you win you will get 400 Rs otherwise no Rs. So, in first case risk is low but benefit is high. In other cases, both risk and opportunity to be benefited are high. Now which one would you like to play? (1=If you win you will get 100 Rs., if you lose you will get 100 Rs., 2=If you win you will get 200 Rs, if you lose you will get 50 Rs, 3=If you win you will get 400 Rs, if you lose you will get no Rs)

Source: Vegetable, Pomegranate and Onion Contract Farming in India: IFPRI Household Survey Questionnaire

Survey Data

The study uses survey data from 643 farmers primarily engaged in onion production, including 113 contract onion growers and 529 independent growers. The farmers also grow several other crops and raise livestock. The survey was conducted during March and April 2016 in the Nashik and Jalgaon districts in Maharashtra, India. Nashik is the largest onion-producing district in Maharashtra, with more than 25% of state onion production. Independent onion growers were chosen randomly from 15 villages in three blocks of Nashik—Nifad, Sinnur, and Baglan. The blocks were classified as low, medium, and high production areas of onion and one block from each category was selected randomly. The sample of independent onion growers was almost equally distributed in Nifad (172), Sinnur (169), and Baglan (188). Five sample villages were chosen randomly from each of the three blocks, and a sample of around 35 households was randomly selected from each sample village. Using a face-to-face interview and different elicitation strategies, the survey collected data on farm and farmer characteristics, cropping patterns, the economics of cultivation, marketing channels, and information on good agricultural practices, assets, incomes, risk perception, and risk attitudes of smallholders.

Risk Elicitation Procedures

Economists and analysts have turned to different survey, experimental, and nonexperimental measures to tackle the relationship between risk behavior and adoption behavior. To assess risk attitudes, this study uses a survey questionnaire and experimental money-denominated lottery-choice gambling exercises. Table 1 presents an example of risk elicitation exercises through money-denominated gambling exercises (RA1 and RA2). Table 2 shows risk-related questions intended to assess RA, such as farmers' self-ratings about risk-taking on financial and investment decisions (RA3), farmers' willingness to take risks on a numeric scale (RA4), and farmers' assessments of themselves on a Likert scale from risk takers to risk avoiders (RA5). Lusk and Coble (2005) suggest that optimal risk-taking behavior depends on both risk attitude and risk perception. To comprehensively analyze the effects of RP on the adoption of risk management practices, we also used farmers' RP measures, including farmers' perceptions of the risk of producing vegetables of low physical quality (RP1), risk of losing production due to weather (RP2), and risk of losing output due to insects or pests (RP3). These RP measures are farmers' ratings of riskiness on a Likert scale 1 to 5, with 5 being the riskiest (Table 2). Specific to risk preference or attitude, scholars have found that direct in-person elicitation provides better individual-specific results (Holt and Laury, 2002; Anderson and Mellor, 2008, 2009). Further, experimental procedures provide control over the circumstances under which the data are generated. The elicited risk measure is influenced by risk

Table 2. Risk Attitude Measures and Other Control Variables

Definition	Conceptual Range	Mean	*N*
Risk attitude [RA] measures			
Risk attitude measure with hypothetical payoff matrix, lottery exercise 1 [RA1]	1,2,3,4,5,6		
Risk attitude measure with hypothetical payoff matrix, lottery exercise 2, [RA2]	1,2,3		
Amount of financial risk that you are willing to take when you save or make investments:	1, 2, 3, 4	2.64	633
1) Not willing to take any financial risks;			
2) Take average financial risks, expecting to earn average returns;			
3) Take above-average financial risks, expecting to earn above-average returns;			
4) Take substantial financial risk, expecting to earn substantial returns [RA3]			
Rate your willingness to take risks in general (Likert scale 1–10, 1, completely unwilling, to 10, completely willing) [RA4]	1 to 10	5.35	625
How do you rate yourself? Risk-avoider or risk taker? (Likert scale 1–5, 1, most risk averse, to 5, least risk averse) [RA5]	1 to 5	2.86	631
Farmer's perceived risk about their farm/production [RP] measures			
Farmer perceptions of the risk of producing vegetables/onion of low physical quality that does not meet buyer requirements (Likert scale 1–5, 5 highest) [RP1]	1 to 5	3.18	1.01
Farmer perceptions of the risk of losing vegetables/onion production due to weather (Likert scale 1–5, 5 highest) [RP2]	1 to 5	3.62	1.19
Farmer perceptions of the risk of losing vegetable/onion production due to pests or insects (Likert scale 1–5, 5 highest) [RP3]	1 to 5	3.08	0.99
Other variables			
Education: years of education of the most educated member in the family	0 to 19	11.64	618
Wealth index[a]	n/a	n/a	643
Location dummies [village1 {=1 if location is village 1, else 0}, village 2,. . . , village 15 {=1 if location is village 15}]; 15 dummy variables for 15 villages	0, 1		528

Notes: : [a]The wealth index was computed using principal component analysis and includes the number of cows, buffalo, sheep, hen, rooms, television, mobile phone, fridge, tube well, power tiller, tractor, threshing machine, sprayer, chaff cutter, car, jeep, van, and motorcycle owned.

preferences and not by heterogeneous assessments of the distribution of outcomes. The money-denominated lottery-choice-type questions in this study follow a good standard risk elicitation format (Holt and Laury, 2002; Anderson and Mellor, 2008). As shown in Table 1, sample farmers were asked to choose one option in every exercise. In one exercise, farmers were given six options:

(i) if you select this option, you will get INR 30,
(ii) if heads, you will get INR 40, if tails, INR 25,
(iii) if heads, you will get INR 50, if tails, INR 20,
(iv) if heads, you will get INR 60, if tails, INR 15,
(v) if heads, you will get INR 70, if tails, INR 10, and
(vi) if heads, you will get INR 80, if tails, INR 0.

Following the Eckel and Grossman (2008) method, each option represents a single gamble (except for the first, which represents a sure event). In each of these gambles, there is a 50% chance of

Table 3. Farmer's Risk Management Decision Variables (*N* = 643)

Farm Management Decisions	Definition	Mean
Farm diversification		
Diversified farm	= 1 if farm also has livestock component, 0 otherwise	0.868 (0, 1)
No. of enterprises raised	Number of crop and livestock enterprises raised on the farm	2.866 (0–8)
Berry index	1 − sum of squared acreage shares: $1 - \sum S_i^2$	0.254 (0–0.775)
Proportion in max crop (concentration)	Crop concentration, proportion of crop acreage in largest crop: [acreage in largest crop/ total crop acreage]	0.766 (0.25–1)
Insurance		
Crop insurance	= 1 if farm participated in any crop insurance, 0 otherwise	0.056 (0, 1)
Livestock insurance	= 1 if farm participated in any livestock insurance, 0 otherwise	0.008 (0, 1)
Contract farming	= 1 if farm participated in contract farming in any crop, 0 otherwise	0.179 (0, 1)
Good agricultural practices (GAPs)		
Number of GAPs adopted	Number of GAPs adopted on the farm	12.667 (0–40)
Improved and gov. recommended seed use	= 1 if farm uses improved varieties of seeds recommended by government or government-approved organizations, 0 otherwise	0.501 (0, 1)
Preventive measures against pest and disease	= 1 if farm takes preventive measures against diseases or pests, 0 otherwise	0.753 (0,1)
Farm and off-farm income		
Share of farm income	Share of agricultural income in total household income	0.804 (0–1)
Share of nonfarm income	Share of nonagricultural income in total household income	0.133 (0–0.925)

Notes: Values in parentheses are minimum and maximum or range, where relevant.
Source: Vegetable, Pomegranate and Onion Contract Farming in India: IFPRI Household Survey Questionnaire.

receiving a high payoff and a 50% chance of receiving a lower payoff. Using the Eckel and Grossman method, we calculate the expected payoff and standard deviation for each gamble. The gambles are designed in increasing order of expected value and standard deviation (i.e., sorted in ascending order of riskiness). Individuals choosing option 1 were risk averse, as this option represents a certain event, while those choosing the last option were considered risk loving, as this option represents a risky gamble.

Risk Management Decisions

The choice of risk management strategies in empirical models is guided by an extensive literature review and theoretical foundation. Most studies suggest that farmers use different strategies cope with risk, including avoiding financial problems, participating in nonfarm work, adopting farming as a primary occupation, contract farming, crop diversification, and crop and livestock insurance (e.g., Hardaker et al., 2015). Diversifying the number of crops and agricultural products has been essential for reducing financial risks (McNamara and Weiss, 2005). Table 3 presents the complete set of risk management decisions used in this study. We consider farm households' various management decisions, capturing four aspects of farm management decisions: farm and enterprise diversification measures, participation in insurance, participation in contract farming, and adoption of good agricultural practices.

We used four measures of farm diversification or specialization. The first measure uses a binary variable—whether a farm is diversified with a livestock component. Crop and livestock mix and integration are standard in subtropical agricultural systems like those in India. Diversification among small and mid-sized farms could be necessary for income diversification, resource utilization, and sustainability (Wright et al., 2012). The second measure uses the number of crops and/or livestock enterprises on the farm to represent diversification. The third measure uses the Berry index, which captures the extent of shared area under leading enterprises. The fourth measure uses a concentration measure: the proportion of crop acreage in the largest crop. Table 3 shows that 87% of the sampled farms are diversified with crop and livestock components and raise on average around three crops and/or livestock enterprises. Farms devote 76% of crop acreage to a single crop and are considered moderately diversified in terms of crop area shares for different crops (indicated by Berry index of 0.25, range of 0–0.77).

Regarding insurance adoption, we used a binary variable with a value of 1 if the farm purchased crop or enterprise insurance and 0 otherwise. Only 5% of the sampled farms adopted crop insurance, indicating that India's agricultural insurance program has yet to gain a high adoption-diffusion level, especially among smallholder, high-value crop growers. Another indicator of risk management is the decision to participate in contract farming. Table 3 shows that around 18% of sampled farms engaged in contract farming. As an essential income diversification measure of risk management, this study considered farm and off-farm income shares to examine off-farm participation as a risk management strategy. On average, off-farm income comprised 13% of total income, while farm income contributed 80%.

Finally, we considered the extent to which sampled farms have adopted good agricultural practices (GAP), which are an indicator of quality-enhancing farm management decisions. The first measure of GAP adoption considers the number of GAPs adopted on the farm.[2] Sampled farm households, on average, adopted around 13 GAPs. The second and third GAP adoption measures include two binary variables related to adopting two specific GAPs: (i) whether a farm uses improved varieties of seeds recommended by government or government-approved organizations and (ii) whether farm adopts preventive measures against diseases and pests. Improved and recommended variety adoption and preventive measures for disease and pests are critical practices in producing high-value crops because they significantly contribute to sustainable yield and marketing. Table 3 shows that 50% of the sampled households adopted recommended improved varieties and 75% used preventive techniques to manage disease and pests.

We analyzed the association and relationship between risk behavior and risk management decisions using correlation and a set of regression models. In each regression, we control for location, wealth, and education variables. Table 2 describes these variables (see the bottom rows under "other variables"). We include an education variable (i.e., years of formal education, for the highest educated family member, range of 0–19). We create a wealth index for each household based on livestock, equipment, farm machinery, phone, vehicles, and other durable assets (except land). Finally, location-specific variables include 15 dummy variables representing smallholders from 15 sampled villages in the study.

Results and Discussion

Risk Attitude and Risk Management Decisions—Correlation and Simple Regression

Table 4 presents the result of correlation and simple regression estimates to test the predictive power of risk attitudes (RA). The correlation and regression results in Table 4 considered a lottery-

[2] The study used a set of 40 adoption questions for standard GAPs.

Table 4. Correlation and Regression Assessing the Predictive Power of Risk Preference on Risk Management Decisions (N = 523)

		OLS Regression with Risk Preference Variable Including Location Dummies	
	Correlation with Risk Preference[a]	Regression Coefficient: Risk Preference[a]	R^2 or Pseudo-R^2
Farm Management Decisions	1	2	3
Farm diversification			
Diversified farm[b]	−0.03	−0.061	0.06
	(0.44)	(0.318)	
No. of enterprises raised	−0.08**	−0.093*	0.07
	(0.034)	(0.100)	
Berry index	−0.11**	−0.026**	0.11
	(0.025)	(0.018)	
Proportion in max crop (concentration)	0.11**	0.025**	0.10
	(0.024)	(0.018)	
Insurance			
Crop insurance	−0.01	−0.004	0.04
	(0.816)	(0.414)	
Contract farming	0.10**	−0.000	0.001
	(0.011)	(0.943)	
Good agricultural practices (GAPs)			
Number of GAPs adopted	−0.22**	−1.309**	0.20
	(0.000)	(0.000)	
Improved and gov. recommended seed use[b]	−0.15**	−0.173**	0.12
	(0.000)	(0.001)	
Preventive measures against pest and disease[b]	−0.22**	−0.213**	0.11
	(0.000)	(0.000)	
Farm and off-farm incomes			
Share of farm income	0.01	0.004	0.04
	(0.88)	(0.684)	
Share of nonfarm income	−0.01	−0.01	0.04
	(0.83)	(0.224)	

Notes: Values in parentheses are *p*-values. Single and double asterisks (*, **) indicate statistical significance at the 10% and 5% level, respectively.
[a]We use risk preference gamble exercise 1 [RA1] in this analysis. Since the risk preference scale is from high risk-averse to less averse, a higher value indicating a riskier decision, usual expected sign of correlation and coefficient is negative, except for the proportion of max crop.
[b]Probit regression was used to account for the binomial dependent variable.

based risk preference measure (RA1) as a single independent variable to assess the relationship and predictive power. Table 4 focuses on the statistical significance of the results rather than the relationship's magnitude. This measure's RA scale is from high risk averse to low risk averse (risk averse to risk taker increment over choices 1 to 6). A higher value of the RA measure indicates a higher willingness to take a risk. Selected farm management decisions can be considered as potential risk management strategies for smallholder households. Therefore, the expected signs of the correlation and regression coefficients are negative for all measures except for the proportion of land allocated to one crop (farm concentration measure).

Results show a statistically significant relationship and expected sign in correlation and regression coefficients for risk management decisions, including diversification, crop insurance, adoption of GAPs, and share of off-farm income in total income. Risk attitude has a significantly

Table 5. Regression Analyzing the Effect of Farmers' Risk Attitude Using Self-Rated Risk Preference Measures (RA3, RA4, RA5) on the Adoption of Risk Management Strategies

Dependent Variable (farm management decisions)	Financial Risk-Taking on Save/Invest (1–4) [RA3] Coefficient 1	Willingness to Take Risk in General (1–10) [RA4] Coefficient 2	Self-Assessment (Likert scale 1–5, risk avoider to taker) [RA5] Coefficient 3
Farm diversification			
Diversified	0.155**	0.066	0.042
	(0.018)	(0.101)	(0.579)
Number of enterprises raised	−0.063	0.148**	0.181*
	(0.243)	(0.000)	(0.005)
Berry index	−0.029**	0.015**	0.025*
	(0.020)	(0.032)	(0.065)
Proportion in max crop (concentration)	0.027**	−0.015**	−0.027*
	(0.024)	(0.019)	(0.033)
Insurance			
Crop insurance	−0.004	−0.004	−0.008
	(0.336)	(0.100)	(0.152)
Contract farming	−0.0011	−0.0004	−0.001
	(0.646)	(0.765)	(0.614)
Good agricultural practices (GAPs)			
Number of GAPs adopted	−1.461**	−0.531**	−0.797**
	(0.000)	(0.000)	(0.000)
Improved and gov. recommended seed use[a]	−0.246**	−0.012	0.105*
	(0.000)	(0.685)	(0.070)
Preventive measures on pest and disease[a]	−0.262**	−0.154**	−0.339**
	(0.000)	(0.000)	(0.000)
Farm and off-farm incomes			
Share of farm income	0.022**	0.033**	0.046**
	(0.038)	(0.000)	(0.000)
Share of nonfarm income	−0.027**	−0.031**	−0.053**
	(0.001)	(0.000)	(0.000)

Notes: Values in parentheses are *p*-values. Single and double asterisks (*, **) indicate statistical significance at the 10% and 5% level, respectively. Each regression is controlled for education variable, wealth index, and 15 village dummies for location. Each regression was estimated using ordinary least squares (for continuous dependent variables) or probit (for binary dependent variables) and robust standard errors.
[a]Probit regression was used to account for the binomial dependent variable.

negative correlation and negative regression coefficient with the number of enterprises raised on the farm and Berry index, both indicators of farm diversification. Further, RA has a significantly positive relationship with the proportion of land allocated to a single crop, an indicator of farm concentration. These results suggest that farmers with higher risk preference levels (lower risk aversion) are less likely to adopt farm diversification strategies. In contrast, farmers with higher risk preference levels are more likely to raise specific crops/enterprises. Predictive power (indicated by R^2, column 3 of Table 4) shows that risk preference explains around 7% and 11% of on-farm diversification and concentration decisions, respectively.

Table 4 shows a significantly negative correlation and regression coefficient of risk attitude on the number of GAPs adopted. Findings indicate that the adoption of GAPs decreases with higher

Table 6. Risk Attitude/Preference Elicitation Based on Gamble Exercise and Implied CRRA

Choice (50/50 gamble)	Low Payoff	High Payoff	Expected Return	Std. Dev.	Implied CRRA[a] Range	CRRA Value Chosen for Regression
Gamble 1	30	30	30.0	0.0	$\rho > 2.97$	3.5
Gamble 2	25	40	32.5	7.5	$1.0 < \rho < 2.97$	1.98
Gamble 3	20	50	35.0	15.0	$0.60 < \rho < 1.0$	0.8
Gamble 4	15	60	37.5	22.5	$0.42 < \rho < 0.60$	0.5
Gamble 5	10	70	40.0	30.0	$0.0 < \rho < 0.42$	0.2
Gamble 6	0	80	40.0	40.0	$\rho < 0.0$	0

Notes: [a]Calculated as the range of *r* in the constant relative risk aversion (CRRA) function $U = (payoff^{(1-\rho)})(1-\rho)$.

risk preference. It is plausible that less risk-averse farmers are more likely to take chances with risky choices and avoid adopting GAPs. Risk attitude has around 20% explanatory power on the decision to adopt several GAPs. Finally, significantly negative correlations and negative coefficients are found for some specific management decisions. For instance, the likelihood of adopting government-recommended improved varieties and adopting preventive measures against pests and diseases decreases with an increase in risk preference. As shown by the pseudo-R^2, risk preference has around 11% and 12% predictive power, respectively, in the above decisions.

Risk Attitude and Risk Management Decisions—Multiple Regression

Table 5 presents the estimated effects of the scale of risk preference (i.e., RA3, RA4, and RA5) on risk management decisions using separate multiple regression models.[3] In all, the study estimated 11 regression models for risk management decisions for the three RA measures (columns 1–3 in Table 5). Additionally, the regression models were controlled for education, 15 location dummy variables, and households' wealth index. The results in Table 5 show that the smallholder's risk attitude significantly influences their risk management decisions. Specifically, consistent with the expectation, results show that RA has a significant effect on the adoption of GAPs, farm work, and nonfarm work. Table 5 also shows that smallholders' RA has a mixed impact on risk management strategies such as diversification or concentration. The table shows a significant negative relationship between RA and farm diversification, measured by the Berry index. In contrast, Table 5 shows a significant positive relationship between RA and farm concentration, measured by the proportion of land allocated to a single crop (RA3, column 1 in Table 5).

The findings regarding the impact of RA on the adoption of GAPs are consistent and significant across the three measures of RA. In particular, RA's effect on adopting the number of GAPs, improved seed varieties, and preventive measures against diseases and pests decrease with increased risk preference or decreased risk aversion. Additionally, findings regarding on- and off-farm work (shares in total income) diversification decisions are consistent with expectations. Specifically, Table 5 shows a significantly negative effect of RA measures (RA3, RA4, RA5) on the off-farm share of total income. Findings suggest that off-farm work, an income diversification strategy, decreases with higher risk-taking behavior. Similarly, a positive and significant coefficient on the share of farm income to total income indicates that the percentage of farm income in total income increases with higher risk-taking or lower risk-aversion behavior among smallholders.

Overall, results from Table 5 suggest that smallholders' risk attitudes (measured by RA3, RA4, and RA) have a significant effect on the adoption of GAPs, participation in off-farm work, farm diversification (Berry index), and farm concentration. However, the relationship between smallholders' risk attitudes and other risk management decisions (e.g., insurance, contract farming, and the number of enterprises) is not significant or consistent across RA measures. Since RA

[3] Recall that farmers' assessment of their risk attitude was on a scale from low risk preference (high risk aversion) to high risk preference (low risk aversion)—RA3, RA4, and RA5 measures.

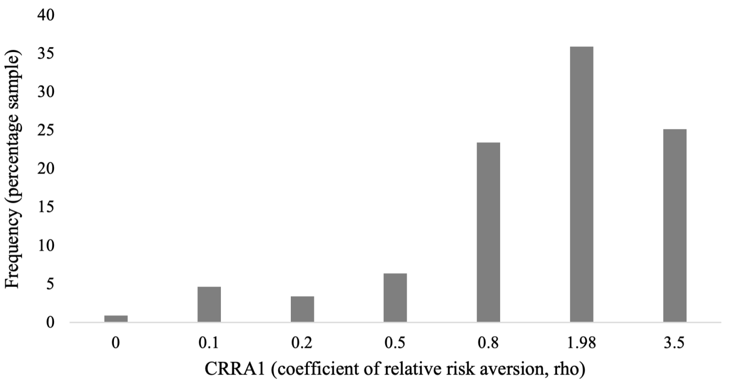

Figure 1. Frequency of Coefficient of Relative Risk Aversion (CRRA) Values on Sample Farmers

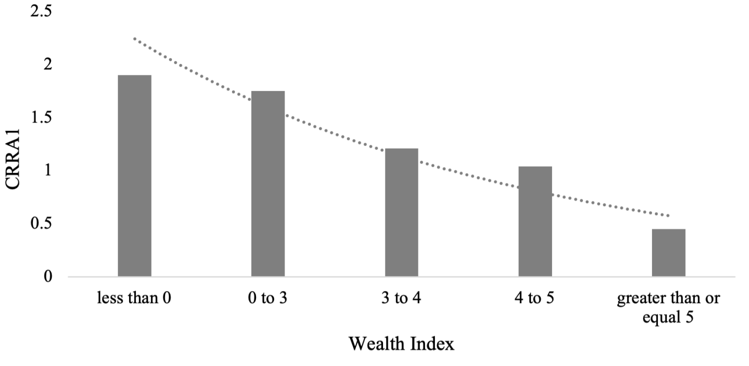

Figure 2. Coefficient of Relative Risk Aversion with Wealth Index Categories

measures in Table 5 are based on smallholders' self-evaluations of RA, some subjective biases are possible, suggesting further examination.

Next, we measure RA using standard risk-elicitation gambling exercises and investigate the impact on smallholders' risk management decisions. Table 6 shows the expected returns associated with each outcome of gambling exercise RA1 and a cut-off range of RA categories consistent with constant relative risk aversion (CRRA, ρ). To compute this range, we use the CRRA utility function $U = \left(payoff^{(1-\rho)}\right)/(1-\rho)$. Table 6 presents six categories of risk aversion based on the CRRA cut-off range, from very risk-loving/risk-neutrality ($\rho < 0.0$) to very high risk aversion ($\rho > 2.97$). Based on the gambling response, we calculate CRRA for each sampled farmer, consistent with techniques used in previous studies (Hellerstein, Higgins, and Horowitz, 2013; Meraner and Finger, 2019). For example, for $\rho > 2.97$, we use CRRA=3.5, for the range $1.0 < \rho < 2.97$, CRRA=1.98, for the range $0.60 < \rho < 1.0$, CRRA= 0.8, for the range $0.42 < \rho < 0.60$, CRRA=0.5, for the range $0.0 < \rho < 0.42$, CRRA=0.2, and for $\rho < 0.0$, CRRA=0. We use these CRRA values to examine the effects of RA1 on risk management decisions.

Figure 1 shows that a large share of smallholders is risk averse (categories for positive ranges of ρ). This is not uncommon, particularly among farm households. Holt and Laury (2002) find the high mass of individuals' level of risk aversion centered around the 0.3–0.5 range. Other studies, including this one, have found a high proportion of farmers in the high risk-aversion range of CRRA (Binswanger, 1980; Cox and Oxaca, 1996; Goeree, Holt, and Palfrey, 2002; Campo et al., 2011). Figure 1 shows that the highest percentage of the sample has CRRA on high risk-aversion range—around 36% of the sample has CRRA 1.98 (range of ρ: 1–2.97), 25% has 3.5 ($\rho > 2.97$), and 5%

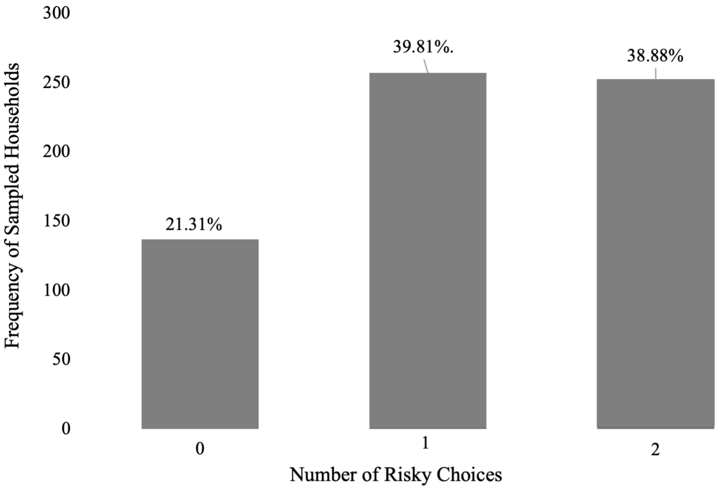

Figure 3. Frequency of Sampled Household on the Number of Risky Choice Decisions

has 0.5 (ρ range: 0.4–0.60). Figure 2 shows the relationship between the wealth-index variable and CRRA.[4]

In addition to the CRRA, we developed two other variables using the RA assessed through risk elicitation (exercise shown in Table 1). First, we introduce *high risk-averse*, a dummy variable that takes a value of 1 if the farmer consistently chooses the lowest risk (safest) choice in every lottery-based gambling exercise RA1 and RA2, and 0 otherwise. Second, the *number of risky choices* (*NRC*) variable is generated by $NRC = RC1 + RC2$, such that $RC1 = 1$ if the smallholder chooses any risky gamble over the safest choice in RA1, and 0 otherwise; $RC2 = 1$ if the smallholder chooses any risky gamble over the safest choice in RA2, and 0 otherwise. Note that $NRC \in \{0, 1, 2\}$. Figure 3 shows that nearly 40% of the sampled farmers can be classified as $NRC = 1$, 39% as $NRC = 2$, and 21% in $NRC = 0$. Finally, there is a 0.15 correlation coefficient between *NRC* and the wealth index variable, suggesting a positive association between smallholders' wealth and risk-taking behaviors.

The three risk preference measures, namely, *high risk-averse*, CRRA based on RA1, and *NRC*, were evaluated in each regression model of risk management decisions, controlling for smallholders' location, education, and wealth (see Table 7). Table 7 shows some interesting findings on the relationship between RA and risk management decisions. Column 1 shows the correlation between RA's effect through *high risk-averse* dummy variable and risk management decisions. The *high risk-averse* variable has a positive and significant coefficient on on-farm diversification decisions (number of enterprises raised, Berry index) but a negative and significant coefficient on the on-farm concentration decision (proportion of largest crop area). This finding suggests that high risk-averse farmers are more likely than others to adopt farm diversification strategies.

Similarly, a positive and significant coefficient of the *high risk-averse* dummy on the adoption of GAPs suggests that high risk-averse smallholders are more likely to adopt a higher number of GAPs. Results reveal that high risk-averse farmers are more likely than low risk-averse farmers to adopt an additional enterprise in farm diversification (magnitude is 0.78) and adopt about 1.5 additional GAPs. Additionally, high risk-averse farmers are more likely to adopt government-recommended improved seed varieties and preventive measures against diseases and pests. The magnitude suggests that high risk-averse farmers are 32% more likely to adopt improved and government-recommended seed varieties and 23% more likely to adopt preventive measures against endemic disease and pests than low risk-averse farmers. This may indicate that high risk-averse farmers not only consider

[4] We found correlation coefficient of -0.16 between the wealth-index variable and CRRA. Thus, from a collinearity standpoint, the correlation is not problematic, making it possible to use the wealth index and CRRA as explanatory variables (regressors) in same regression.

Table 7. Effect of Risk Attitude-Based Alternative Measures on Risk Management Decisions

	High Risk-Averse Dummy[a]		Relative Risk Aversion, (CRRA)		Number of Risky Choices	
Dependent Variable	**1**		**2**		**3**	
(farm management decisions)	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Farm diversification						
Diversified	0.058	0.199	0.065	0.069	−0.018	0.107
Number of enterprises raised	0.783**	0.158	0.162**	0.058	−0.195**	0.089
Berry index	0.154**	0.032	0.035**	0.012	−0.050**	0.018
Proportion in max crop (concentration)	−0.158**	0.031	−0.034**	0.011	0.049**	0.017
Insurance						
Crop insurance	0.275	0.383	0.032	0.147	−0.164	0.225
Contract farming	0.004	0.006	−0.0004	0.002	0.0001	0.003
Good agricultural practices (GAPs)						
Number of GAPs adopted	1.429**	0.513	1.145**	0.179	−1.231**	0.281
Improved, gov. recommended seed[b]	0.321**	0.150	0.219**	0.054	−0.144**	0.082
Preventive measures on pest and disease[b]	0.233*	0.142	0.156**	2.79	−0.262**	0.088
Farm and off-farm incomes						
Share of farm income	0.089**	0.032	0.011	0.011	−0.044**	0.018
Share of nonfarm income	−0.064**	0.023	−0.001	0.008	0.013	0.012

Notes: Values in parentheses are *p*-values. Single and double asterisks (*, **) indicate statistical significance at the 10% and 5% level, respectively. Each regression is controlled for education variable, wealth index, and 15 village dummies for location. Each regression was estimated using ordinary least squares (for continuous dependent variables) or probit (for binary dependent variables) and robust standard errors.
[a]High risk-averse dummy variable =1 if farmer consistently chooses the lowest risk (safest) choice in all risk preference gamble exercise [RA1] and [RA2], 0 otherwise.
[b]Probit regression was used to account for the binomial dependent variable.

enterprise diversification as a risk management tool but also consider adopting some quality-enhancing sustainable practices on the farm.

Using the CRRA categories, the findings are generally consistent with the overall conclusions presented above. Using cut-off range categories of CRRA (Table 7, column 2), the results consistently support the likelihood of enterprise diversification and the likelihood of adopting GAPs and some quality- and sustainability-enhancing practices (e.g., use of government-recommended seed variety and preventive measures against endemic disease and pests) increasing with higher risk aversion and the likelihood of crop concentration decreasing with higher risk aversion. However, results regarding farm and nonfarm income shares in total household income are somewhat counterintuitive. The bottom rows of column 1 show that high risk-averse farmers are more likely to derive a majority of their household income from farming. This result is in contrast to the notion that off-farm work (or income) is often used as a risk management tool. However, note that the sample is specific to high-value crop (onion) growers. Additionally, for most smallholder households, farming is their primary occupation, and they pay greater attention to revenue from onion crop production.

The *number of risky choices* (*NRC*) variable as a measure of RA results in Table 7 (column 3) is generally consistent with expectation and supports the findings from columns 1 and 2. Results show that less risk-averse farmers are more likely to have a less diversified farm (fewer enterprises, lower Berry index) and more likely to concentrate acreage on one crop (positive coefficient of the max crop). Additionally, results reveal that an increase in *NRC* decreases the adoption of GAPs, the likelihood of some quality- and sustainability-enhancing agricultural practices, and the share of farm income in total household income.

Table 8. Effects of Farmers' Risk Perception about Their Farm/Production (PR measures) on the Adoption of Risk Management Strategies

Dependent Variable (farm management decisions)	Perceived Risk of Vegetable Production with Low Quality (Likert, 1–5) [RP1] Coefficient	Perceived Risk of Losing Production Due to Weather (Likert, 1–5) [RP2] Coefficient	Perceived Risk of Losing Production Due to Insects/Pests (Likert, 1–5) [RP3] Coefficient
Farm diversification			
Diversified	−0.059	−0.125*	−0.130
	(0.458)	(0.083)	(0.121)
Number of enterprises raised	0.216**	0.040	0.201**
	(0.001)	(0.484)	(0.003)
Berry index	0.037**	0.016	0.028*
	(0.013)	(0.226)	(0.072)
Proportion in max crop (concentration)	−0.036**	−0.014	−0.030**
	(0.011)	(0.247)	(0.046)
Insurance			
Crop insurance	−0.180	−0.096	0.034
	(0.297)	(0.523)	(0.852)
Contract farming	−0.0035	−0.003	−0.001
	(0.221)	(0.270)	(0.732)
Good agricultural practices (GAPs)			
Number of GAPs adopted	−1.190**	−0.527**	−1.143**
	(0.000)	(0.004)	(0.000)
Improved and gov. recommended seed use[a]	−0.090*	−0.117**	−0.119
	(0.010)	(0.025)	(0.845)
Preventive measures on pest and disease[a]	−0.288**	−0.006	−0.333**
	(0.000)	(0.917)	(0.000)
Farm and off-farm incomes			
Share of farm income	0.056**	0.057**	0.042**
	(0.000)	(0.000)	(0.002)
Share of nonfarm income	−0.054**	−0.052**	−0.0549**
	(0.000)	(0.000)	(0.000)

Notes: Values in parentheses are *p*-values. Single and double asterisks (*, **) indicate statistical significance at the 10% and 5% level, respectively. Each regression is controlled for education variable, wealth index, and 15 village dummies for location. Each regression was estimated using ordinary least squares (for continuous dependent variables) or probit (for binary dependent variables) and robust standard errors.
[a]Probit regression was used to account for the binomial dependent variable.

Risk Perception and the Adoption of Risk Management Strategies

Table 8 presents the effects of farmer's risk perception (RP) on risk management decisions. RP includes three farm production risks: risk of low-quality vegetable production (RP1), risk of losing production due to adverse weather (RP2), and risk of losing production due to insects or pests (RP3). The RP measures are on a Likert scale of 1 to 5, with 5 being the riskiest. Table 8 shows the positive coefficients of RP1 and RP3 on farm diversification risk management strategies (measured by the number of enterprises and Berry index). Additionally, findings show a negative coefficient of RP1 and RP3 on the farm concentration equation (proportion in max crop). Results suggest that the likelihood of farm diversification through the adoption of a higher snumber of enterprises and the adoption of multiple crops increases with a higher perceived risk of low-quality production or higher perceived risk of losing agricultural production due to insects or pests.

Interestingly, Table 8 shows that RP measures have negative effect on the adoption of GAPs. Findings suggest that smallholders are less likely to adopt GAPs if they have higher RP for low-quality production, losing crop production due to weather, or losing agricultural output due to insects or pests. Additionally, smallholders with higher RP are less likely to adopt improved varieties or preventive measures on pest-disease. The above finding may be a little counterintuitive, but a plausible explanation may stem from the investments required for good or quality-enhancing practices. For instance, in anticipation of a higher risk of adverse production, perhaps farmers care less about GAPs but more about getting some produce—the idea of "food security first." Another interesting finding in Table 8 is the effects of RPs on income diversification strategies. The table shows significant positive impacts of RPs on the share of farm income in total income. The impact of RPs on the share of off-farm income in total income is negative and significant. Findings suggest that smallholders with higher RP of low-quality production, losing production due to weather, and losing production due to insect or pest infestation are more likely than their counterparts to focus on on-farm activities. The finding is interesting for onion growers in India because the agricultural-related risk is likely to be known or perceived by farmers dependent on agriculture as their primary sources of income. The results may be driven by the fact that a higher share of smallholders in the sample indicates farming as their primary occupation.

Note that the study focused on RA and RP measures, elicitation and estimation, and the effect of RA and RP and predictability power in explaining farmers' adoption of risk management decisions. However, due to data limitations on a specific set of variables and the cross-sectional nature of data, the study could not use panel data and instrumental variable methods. Future studies could critically analyze the in-depth cause and effect relationship, possible two-way causality, or selection bias problems. However, we note that this study's findings should be interpreted as the estimates mainly guided through association or correlation-based methods rather than critical cause and effect relationships.

Summary and Conclusions

This study investigated the extent to which risk management strategies are driven by farmers' perceptions of risk and risk attitude, using growers of high-value crops in India as a case. We use risk attitude measures, including methods based on direct self-reported risk attitudes and estimates based on experimental money-denominated lottery-choice gambling. The results are sensitive to which risk attitude measure is used, where the gambling risk attitude measures gives the most significant and intuitively expected results. From both theoretical and empirical perspectives, we anticipate that farmers' increasing risk perception will positively influence their intention to implement risk management strategies. In contrast, increasing risk preferences (lower risk aversion) will negatively affect their choice to implement risk management strategies (van Winsen et al., 2016). Our findings generally support these expectations. Risk-seeking or risk-neutral farmers are less likely than risk-averse farmers to adopt farm diversification strategies. Further, the likelihood of implementing risk management strategies increases with a higher perceived risk of low-quality production and of losing production due to insects or pests and/or bad weather.

Somewhat counterintuitively, our findings show that high risk-averse farmers likely had a higher income share from agriculture and a lower percentage from nonfarm incomes, contradicting the notion of using off-farm income as a risk management tool. As expected, farmers focused more on on-farm activities than off-farm income generation activities when they perceived higher risk in production. The study also looked at GAPs adoption and found that high risk-averse farmers are more likely than more risk-preferring farmers to adopt GAPs. The results showed a negative effect of risk perception on the adoption of GAPs, which may be because of the large investments required for good or quality-enhancing practices.

This study's practical implication is that farmers' choice of risk management strategies depends on their expected direct effect on practical farming and economic outcome. Risk management strategies depend on farmers' perceived risk in production and their risk attitudes. For example, government intervention in one aspect that influences the real risk in farming may affect both farmers' perceived risk, their risk attitudes, and the ranking of the risk management strategies. Therefore, in general, farm advisers and policy makers should consider all of these aspects to develop or support risk management strategies.

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