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Social capital and production risk: examining the association using the case of irrigated rice farms in Northern Thailand

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Abstract Results showed that higher perceived social capital in terms of interpersonal trust and network relationships are negatively associated with variability in production. The observed association can be attributed to the social capital capacity for resource generation and networking, which help mitigate potential risks. The study provided evidence of the importance of developing and strengthening the social capital of farming communities in supporting farmers' risk management. Especially among farmers with less access to information, the farmer's network facilitated the knowledge-sharing on farming innovations and improved practices.

Keywords: Stochastic frontier, Social capital, Risk, Production, Rice

Introduction

Thailand has recognized the importance of agriculture in achieving several SDG goals (e.g., no poverty, zero hunger, economic growth, and responsible production). For Thailand, the Sufficiency Economy Philosophy (SEP) has been the primary framework in the country's policy formulation through the National Economic and Social Development Plan (NESDP), which also aligns with achieving the SDG goals. The SEP considers four major impacts of any policies and programs: material, cultural, environmental, and social (Jeenaboonrueang, 2019).

The study focused on the social aspects using the social capital concept and its link to production risk. Following the study of Yang *et al*. (2020), the two subdimensions of social capital on the perceived interpersonal trust and network relationship was used. The network relationship refers to farmers' connected actors with whom they often interact in seeking information and resources (Rockenbauch *et al*., 2019; Yang *et al*., 2020). While interpersonal

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trust is the farmer's dyadic relationship, often characterized by reciprocity with their family, friends, or community members (Nolan *et al*., 2017). In a broader dimension of social capital, network relationship and interpersonal trust are highly related to bridging social capital (Kawamoto and Kim, 2019; Llones *et al*., 2021) and bonding social capital (Cofré-Bravo *et al*., 2019; Leonard, 2004; Mathews, 2021), respectively.

The growing body of empirical research on social capital indicates the growing interest in social capital, especially in the development process. For instance, social capital has been documented to increase political participation (Collier, 2021; Putnam, 2000), promote cooperative movement (Cofré-Bravo *et al*., 2019; Llones *et al*., 2021), and resource generation (Auer *et al*., 2020; Choi and Chang, 2020). These effects attributable to social capital are vital in promoting resiliency and adaptability, particularly in the agricultural sector (Osborne-Gowey, 2021).

Thailand's agricultural sector's share of GDP has been declining since the 1960s, the worsening effects of climate change coupled with the disruptions brought by the Covid-19 pandemic are expected to pull down the country's agricultural output. Several of these climatic risks experienced by farmers in the country include flooding, drought, and unpredictable weather conditions (Llones and Suwanmaneepong, 2021). National policies and programs (e.g., Organic Agriculture Certification, one tambon one product (OTOP), good agricultural practices) have been implemented to promote sustainability and mitigate the impact of emerging risks in the agricultural sector. However, the outcomes are still below the projected targets. The allocated resources to agriculture are insufficient partly due to the country's limited resources constraining the implementation of different agricultural projects (Lee, 2021).

With the limited resources from the national government, farmers' social capital promoting cooperation and connection among farming communities would be necessary for improving livelihoods. Putnam (2000) emphasized that "social capital is a stock of social trust network, and values which people can draw in order to improve livelihoods and to pursue shared objective" (Cofré-Bravo *et al*., 2019). The current condition of the increasing risk is faced by farmers and recognizing the potential impact of social capital in agricultural development. The study aimed to investigate the association of farmers' production risk and social capital with its sub-dimension on the perceived interpersonal trust and network relationship drawing from the case of irrigated rice farms in Chiang Rai province Northern Thailand.

Materials and methods

Study area

The rice farmers in Chiang Rai province in northern Thailand were investigated as the case study area. Farmers rely mainly upon the Mae Lao Irrigation Project (MLIP), which covers 29,440 hectares of rice cultivation area as shown in Figure 1 (Wongtragoon *et al*., 2010). The Mae Lao River flows in Wiang Pa Pao in the north and north-east in Mae Suai, Mae Lao, Muang, and Wiang Chai districts. Accessing the Mae Lao irrigation requires farmers to be a member of a water user group. Establishing a water user group is part of a scheme on shared responsibilities of managing the irrigation infrastructure under the participatory irrigation management (PIM) program.

The MLIP enables farmers to produce rice during the dry season, which occurs from March to May while serving as supplementary during the rainy season. The production data of 294 rice paddy farmers covering the 2020-2021 rice production was collected. In addition, the perceived interpersonal trust toward group members and their perceived relationship with their connected network were also gathered. The descriptive summary of the collected production data and sociodemographic variables are summarised in Table 2 of the results section.

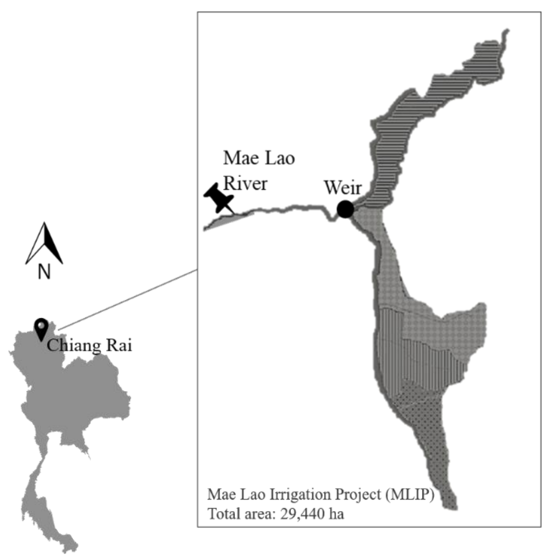

Figure 1. Map of the study area in Mae Lao Irrigation Project in Chiang Rai province, Northern Thailand

Stochastic frontier analysis with risk specification

The analytical process used by Alam *et al*. (2019) and Chang & Wen (2011) was adopted in the study, which is derived from the Just and Pope (1979) stochastic production function with risk specification. The JP model (Just and Pope, 1979) distinguishes how inputs affect mean output and the variability in production. A more generalized flexible form of the JP model suggested by Kumbhakar (2002) is specified as follows:

$$y_1 = f(x_i; \beta) + g(x_i; \psi)v - q(z; \delta)u \quad (1)$$

The y_i denotes the production output; $f(x_i; \beta)$ is the production function which represents the effects of the input on the mean output; $g(x_i; \psi)$ is the variance function reflecting the effects of inputs on the production variance, and v is the double-sided random error that represents production risk, which is assumed to be $iid \sim N(0,1)$; $q(x;\ \delta)$ is the inefficiency function and u is the nonnegative random variable capturing inefficiency. Following equation (1), the study's empirical production follows a Cobb-Douglas form specified as:

$$y_i = f(\beta_0 + \sum_{j=1}^{4} \beta_j \ln x_{ij}) \quad (2)$$

Wherein y_i is the rice production in kilogram per rai and the x_j are the jth inputs such as the seeds, fertilizers, family, and hired labor. For the variance function as an estimate of the production risk, the function is specified as:

$$\sigma_v^2 = g\left(\psi_0 \prod_{j=1}^{6} z_j^{\psi_j}\right) \quad (3)$$

The z_j are the explanatory variables which assumed to explain the variability in production due to the production risk, such as the seeds, family and hired labor, farm size, and the social capital domain on perceived interpersonal trust and relationship network. Then, following Kumbhakar (2002), the parameters in equations (2) and (3) were estimated using the log-likelihood function specified below.

$$lnL = constant - \frac{1}{2}\sum \ln[g(x_i; \psi)v + q(z_i; \delta)u] + \sum \ln \Phi\left(-\frac{\varepsilon_i \lambda_i}{\sigma_i}\right) - \frac{1}{2}\sum \frac{\varepsilon_i^2}{\sigma_i^2} \quad (4)$$

In estimating the stochastic production function with risk specification using the log-likelihood function in equation (4), we used the R packages sfaR by Dakpo *et al*. (2021) and the ggplot2 by Wickham (2016) for the plots presented. The R codes in estimating the model, and presented plots can be accessed using the link [t.ly/2nNr].

Exploratory factor analysis

An exploratory factor analysis (EFA) with a varimax rotation was used to assess the surveyed items in identifying the indicators for the composite summed scores for the social capital domains. In addition, we used the Kaiser-Meyer-Okin (KMO) and the Bartlett test to assess the suitability of the items for factor analysis outlined in Table 1.

The Bartlett test was employed to test the significance of the correlation among at least some indicator variables (Auerswald and Moshagen, 2019). At the same time, KMO was used to assess the proportion of variance in the variables that might be due to an underlying factor (Hair, 2019). The variables used as indicators in reflecting the factors on interpersonal trust and relationship networks is summarized in Table 1.

Table 1. Indicator variables used in measuring interpersonal trust and relationship networks

Items	Description
Interpersonal trust	
IT01	In the village, people generally trust each other.
IT02	The relationship among people in this neighborhood is harmonious.
IT03	Members of the water user group go along with each other.
IT04	Members of the water user group trust each other.
Relationship network	
RN01	Members communicate or interact with each other.
RN02	Members communicate or interact with the WUG officer.
RN03	Members communicate or interact with the irrigation staff.
RN04	WUG communicated or interacted with local government officials

Results

Sociodemographic characteristics and production input-output variables descriptive statistics

The descriptive statistics of the production input-output variables and the sociodemographic characteristics of the surveyed farmers were summarized in Table 2. The average production area ranged from 1-32 rai, wherein the average rice yield was 740.91 kg per rai. The fertilizer application rate (e.g., urea, NPK) was 36.69 kg per rai, while seed application on 17.42 kilogram per rai. On the other hand, labor input consisted mainly of family labor, with an average of 77 hours per rai, while hired labor at 10.48 hours per rai. Moreover, farmers in the study area had lower formal education but high average farming years of experience. The majority of 61 percent were found to be at primary school, while 29 percent attended high school.

Table 2. Descriptive statistics of the sociodemographic and production input-output variables

Variable	Mean/Percent	Std. Dev	Min	Max
area	10.62	6.46	1.00	32.00
yield (kg/rai)	740.91	160.57	285.71	1583.33
seed (kg/rai)	17.42	4.88	8.00	50.00
fertilizer (kg/rai)	36.69	14.96	12.50	100.00
family labor (hr/rai)	77.13	56.80	4.00	288.00
hired labor (hr/rai)	10.48	19.79	1.00	258.00
farming years	30.91	14.34	1.00	63.00
educational level				
no formal education	5%			
primary	61%			
high school	29%			
college level	5%			

Note: 1 hectare = 6.25 rai

Social capital domains measurement items

The results of the overall KMO test (KMO=0.814) were found to be at the acceptable threshold of 0.70 and above, while Bartlett's test was statistically significant (χ^2 =1444.39, df=28, $p < 0.01$) (Hair *et al.*, 2020; Hu and Bentler, 1999). Each item considered as an indicator, a cut-off value of 0.70 was used for the factor loadings, and any potential high cross-loadings were removed. The results of the factor analysis and the items used to measure the perceived interpersonal trust and relationship network are shown in Table 3. A two-way plot of the social capital domains. The plot showed highly correlated items are grouped according to their expected dimension or latent factor.

Table 3. Factor analysis of the social capital items

Factors	Items	Loadings	KMO	Cronbach's alpha
Interpersonal trust				0.90
	IT01	0.81	0.80	
	IT02	0.84	0.79	
	IT03	0.83	0.81	
	IT04	0.78	0.81	
Relationship network				0.88
	RN01	0.71	0.82	
	RN02	0.89	0.79	
	RN03	0.82	0.85	
	RN04	0.73	0.84	

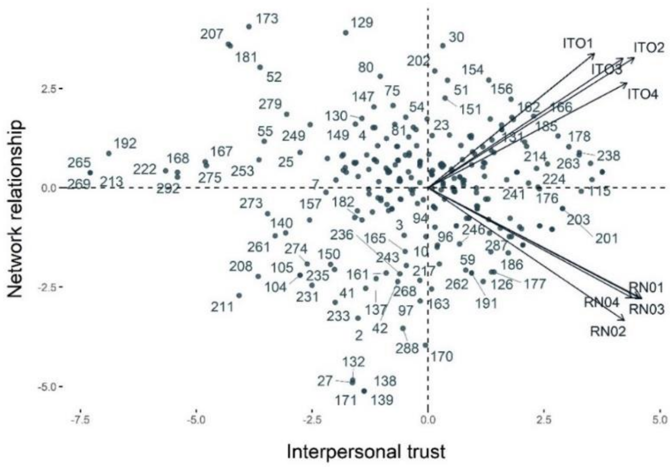

Figure 2. Biplot of the network relationship and interpersonal trust items using factor analysis. Correlated variables are grouped, and the distance from the origin to the items (i.e., arrow's length) indicates the quality of the items

Perceived interpersonal trust and relationship network

The percent frequency of farmers' perceived interpersonal trust and relationship network illustrated in Figure 3. Approximately 60 percent of the sampled farmers expressed trust toward members of the water user group (i.e., percent of responses above the neutral scale used in the survey questionnaire), of which 21-28 percent have complete trust. At the same time, 4-7 percent of farmers show less perceived trust with other members, and 16 percent are neutral on whether they trust or not the group members. Whereas 76 percent of the sampled farmers expressed trust toward the neighborhood/village, 22-29 percent strongly agreed. Approximately 1-5 percent of farmers expressed distrust toward the neighborhood.

Regarding the network relationship items, farmers' networks consisted of irrigation officers, government and non-government organizations, private institutions, academe, and farmer groups. Although 50 percent of farmers showed interactions with government officers, only 14 percent expressed strong communication and interaction. While 17-19 percent of farmers found less interaction with government officers or extension workers. Communication and interaction with government extension workers is primarily involved farm consultations.

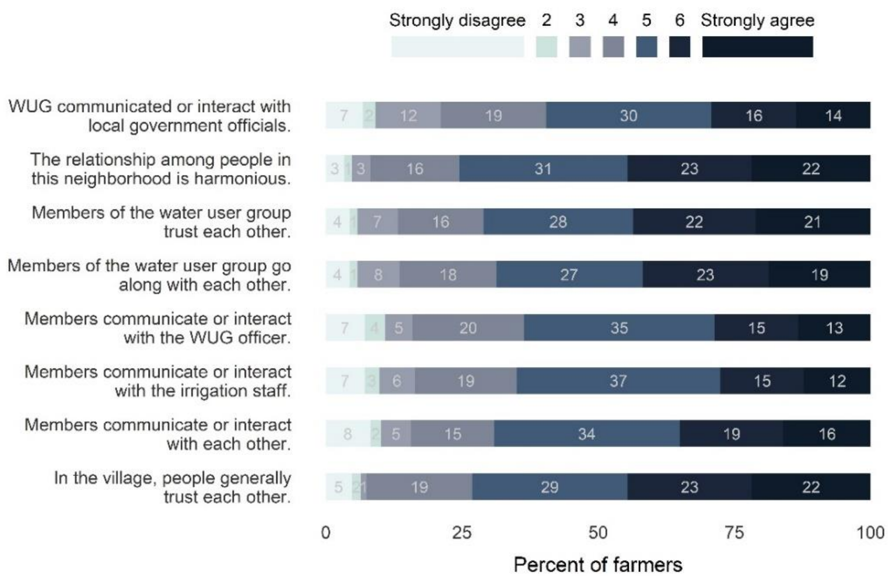

Figure 3. Percent frequency of farmer's responses on perceived interpersonal trust and network relationship items

Production risks and social capital domains

The stochastic production frontier with risk specification in Table 4 summarised the parameter estimates for the deterministic production component and the variance component of the estimated model. All the inputs were nonnegative, indicating that both models shown in Table 3 followed the monotonicity condition. The family labor was slightly higher than the hired labor and had the highest marginal product. This implies that family labor contributed the largest to production and followed by the fertilizer input and the seed input. Overall return to scale was found to be 0.891 at the sample mean, indicating that farmers were operating under decreasing return to scale. It suggested that the increasing percentage in input use was less than the percentage increased in production.

In terms of the input's relation to production risk, the variance function showed that labor inputs were significantly and negatively associated. It indicated that family and hired labor were risk-decreasing input among the sampled farms. Although not significant, increased in seed use was negatively associated with production risk, while farm size was significant and a risk-increasing input. It can be attributed to a larger input and managerial requirements associated with larger farms.

The possible association of the social capital domains with production risk was investigated. The model 1 and model 2 estimated the SFA with risk specification for the perceived interpersonal trust and relationship network. The perceived interpersonal trust was negatively associated with production risk, however not significant in the case of the sampled farmers. On the other hand, the relationship network is negatively associated with production risk and was significant. The result shows how developing network relationships could help to mitigate the impact of risks in production.

Table 4. Production function and the effects of the perceived interpersonal trust and network relation

	Model 1		Model 2	
Deterministic function	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	0.503***	0.065	0.498***	0.060
ln seed	0.089	0.173	0.084	0.165
ln fertilizer	0.227***	0.085	0.231***	0.082
ln family labor	0.292***	0.042	0.290***	0.041
ln hired labor	0.283***	0.053	0.277***	0.051
Variance function				
Intercept	-3.188**	1.247	-2.742**	1.166
ln seed	-0.094	0.881	-0.124	0.858
ln family labor	-1.241***	0.305	-1.225***	0.299
ln hired labor	-0.982***	0.373	-0.959***	0.353
Farm size	0.238***	0.047	0.246***	0.046
Interpersonal trust	-0.03093	0.156		
Network relation			-0.163**	0.075

Significance level: $*** \, p < 0.01$; $** \, p < 0.05$; $* \, p < 0.10$

The farmers' perceived interpersonal trust and relationship network with production risk were estimated. The empirical cumulative density function (ECDF) of the production risk share in the total production variability were shown in Figures 4 and 5. The total production variability was assumed ot be composed of variability due to production risks and variability due to farmers' inefficiency.

The mean percentage contribution of production risk to the total production variability was 20 percent for the sampled farms. This implies that a larger portion of production variability was due to farmers' level of production inefficiency. The production risk distribution of farmers with lower perceived interpersonal trust showed a higher percentage of production risk as a share of production variability. For example, the proportion of farmers with lower perceived personal trust was less than or equal to 50 percent share of the production risk which was larger than farmers with higher perceived interpersonal trust. The result suggested that the sampled farmers with lower perceived interpersonal trust faced a higher production risk than their counterparts.

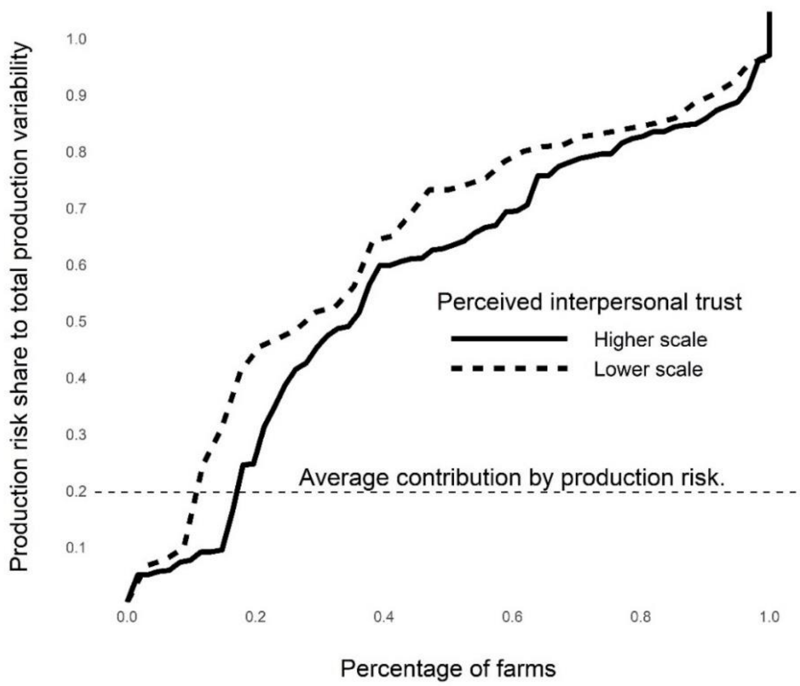

Figure 4. The cumulative density function of the production risks shared to total production variability by the farmer's perceived interpersonal trust

The production risk distribution by perceived relationship network, the mean percentage contribution was 19 percent for the sampled farms. The perceived interpersonal trust of farmers with lower relationship networks faced a higher production risk than those with higher relationship networks.

The results may reflect mutual learnings like farm management, innovations, and new practice which may help to minimize the potential impact of different production risks associated with farming. In addition, a strong network relationship allowed knowledge diffusion through knowledge sharing within the farming network.

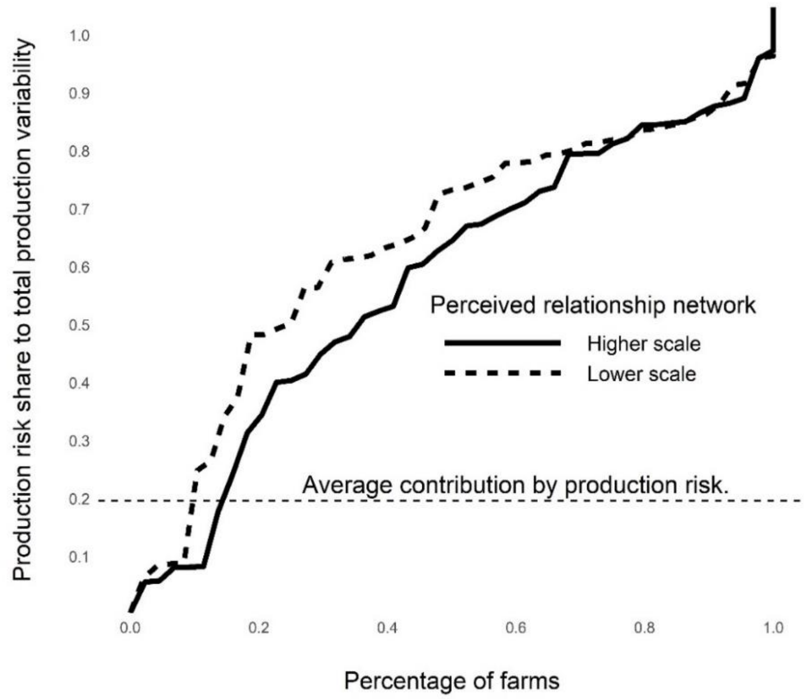

Figure 5. The cumulative density function of the production risks shared to total production variability by the farmer's perceived relationship network

Discussion

Thailand's agricultural sector takes a vital role in achieving the SDG goals of the country in line with the Sufficiency Economy Philosophy (SEP) of the country. Four major impacts are focused on by SEP such as material, cultural, environmental, and social impacts (Jeenaboonrueang, 2019). In the study, we focus on the social aspects using the sub-domain of social capital (i.e., interpersonal trust and network relation) and its relations to farmers' production risks using a stochastic production function with risk specification.

Increasing empirical evidence on social capital has been documented to influence the production decisions of a farming community, especially in rural areas (Collier, 2021; Llones *et al*., 2022; Osborne-Gowey, 2021). People in rural communities often know each other and are characterized by high interpersonal relationships (Cofré-Bravo *et al*., 2019; Yang *et al*., 2020). In this study, we found that a high perceived interpersonal trust among sampled farmers is negatively associated with production risk. Although results show that the association between perceived interpersonal trust and production was found to be statistically not significant, looking closely at the distribution of the production risk's share to total production variability, farmers with lesser perceived interpersonal trust faced higher risk.

Higher perceived interpersonal trust within the farmers' social network facilitates information dissemination, such as specific farm operations, innovations, and risk-reducing practices (Cadger *et al.*, 2016; Cofré-Bravo *et al.*, 2019; Skaalsveen *et al.*, 2020). For instance, during group meetings, farmers discuss and share their relevant experiences on farming-related issues. Information flows are facilitated, and interpersonal trust is developed through daily conversation and neighborly visits to each farm. In addition, farmers seek and acquire information from other farmers they trust (Collier, 2021). While there are agricultural experts or extension workers in the study area, less than 20 percent of the sampled farmers received regular consultations. The reason is partly due to the vast land coverage and the ratio of available personnel to farmers needing agricultural advice. Thus, farmers turn to get advice from relatively more knowledgeable farmers within their farming network as these are more convenient and much more accessible for farmers.

The advice-seeking behavior among fellow farmers requires high interpersonal trust to create an atmosphere of mutual support within the farming network (Yang *et al*., 2020). The concept of mutual support among farmers is particularly relevant in the study area, given that farmers are required to be a member of the water user group to access the irrigation services under the Mae Lao Irrigation Project. The infrastructure maintenance and irrigation management among group members are done collectively. These collective actions performed by farmers require a high level of trust that each member performs their expected responsibility, participation in the irrigation operation, and non-deflection. For instance, any disruptions in the upper branch of the irrigation canal (e.g., illegal gate operation) will cause problems at the lower branches. These irrigation problems that can be partly attributed to a lack of interpersonal trust among members affecting the collective management and operation of the irrigation add risk to farmers' production (Chaudhry, 2018; Llones *et al*., 2022).

On the other hand, the sub-domain network relationship of social capital is highly associated with resource generation (Micheels and Nolan, 2016; Yang *et al.*, 2020). Greater networks allow farmers in the study area to obtain technical support and capital from their network members, which helps in mitigating potential risks. As the result shows, farmers with greater network relationships face lesser production risk than those with lower relationship networks. Several of these networks are the government (e.g., Royal Irrigation

Department, Ministry of Agriculture), NGOs, private institutions, and the academe.

Farmers with greater network relationships have more capacity to acquire information and resources. For example, during the dry season, an estimated 20 percent of the surveyed farmers participate in off-farm work to complement rice production. At the same time, some do not cultivate rice during the dry season and opt to do off-farm or non-farm activities in urban areas. In this situation, the farmer's network relationship in seeking alternative or additional livelihood activities provides additional financial resources to mitigate the impact of drought during the dry season. In addition, networks such as academe, government, and NGOs that provide extension services, farm technologies, and practices help mitigate farm risks related to crop management, post-harvest, and marketing (Micheels and Nolan, 2016). Like the Chilean farmers, Cofré-Bravo *et al*. (2019) found that farmers with a greater network can be financially flexible in their innovation investment by connecting with banks, export firms, and government agencies. Furthermore, being flexible in sourcing other financial resources aside from one's own provides a great safety net from risk.

Developing interpersonal trust and the network relationship of the social capital domains helps improve productivity, acquire new resources, and provide a safety net for potential risks. Utilizing farmers' social networks to diversify income sources is very timely, given the climatic changes experienced globally coupled with the pandemic restrictions. Increasing the opportunities for alternative or multiple livelihood activities for farmers can be an effective coping strategy in minimizing income variability and risk associated with farming. While there is no panacea, combining existing government and future programs with an emphasis on developing the farming community's social capital leads to better policy outcomes.

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