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VULNERABILITY ASSESSMENT TO CLIMATE-RELATED HAZARDS OF RICE FARMER HOUSEHOLDS IN THE PHILIPPINES USING LOSS RATIO

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ABSTRACT

The Philippines faces increasing climate-induced risks to rice production, emphasizing the need for vulnerability assessment as a basis for evidence-based adaptation and policy development. This study introduces an alternative approach where the vulnerability index is defined as the probability that the loss ratio exceeds a specified threshold. A fractional logit regression model was used to identify factors influencing farmers' loss ratios. Using multi-stage stratified random sampling, 100 respondents were selected from major rice-producing municipalities across 11 provinces in key rice-growing regions in the Philippines. Data were collected from July 2022 to February 2023 using a structured questionnaire. Results indicate that a higher share of rice income in total household income, exposure to climate hazards such as typhoons and droughts, and participation in crop insurance are all associated with an increased loss ratio. Conversely, higher loan amounts, access to agricultural training, and government assistance significantly reduce the loss ratio. The findings underscore the critical role of institutional support, financial access, and adaptive capacity-building in minimizing climate-related losses and enhancing the resilience of rice-farming communities in the Philippines.

Key words: rice production, agriculture, climate change, rice farming, vulnerability index

INTRODUCTION

The Philippines is vulnerable to climate change (USAID 2023) and is directly exposed to several climate-related hazards (World Bank 2013 2015; Evangelista et al. 2015). Agriculture, a key sector in the country, is highly vulnerable to climate-related hazards, with rice production being the most affected. Rice is a major crop and a staple food in the Philippines. It plays a vital role in the national economy, contributing an average of 23.4% to the gross value added of the Agriculture, Forestry, and Fishing (AFF) sector from 2000 to 2020[1]. However, climate change can highly affect rice production as it is one of the most sensitive agroecosystems to climate variability (Lansigan et al. 2000; Saud et al. 2023). The effects of climate-related hazards pose significant risks to food security and the livelihoods of rice farmers, as these hazards can damage rice production and even wipe out production depending on the intensity, duration, and timing.

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[1] Author's calculation of PSA annual data at constant 2018 prices (https://openstat.psa.gov.ph/Database/Agriculture-Forestry-Fisheries).

Typhoons and extreme temperatures can severely damage rice harvests and threaten farmers' incomes. According to Lansigan et al. (2000), 82% of the loss to rice production from 1970 -1990 was due to typhoons, floods, and droughts. In addition, typhoons have been the cause of the production loss of 12.5 million tons of rice since 2001(Blanc and Stobhl 2016). On the other hand, Wang et al. (2021), Diaz et al. (2021), and Sharma et al. (2022) have demonstrated the negative impact of rising temperatures on rice yields.

Rice production is a main source of income for most Filipinos in rural areas (Rebojo et.al. 2023), and exposure to various climate-related hazards and damage to rice harvest leads to significant loss of farmers' income. Most rice farmers in the Philippines are small-scale farmers, each owning an average of 1.2 hectares of farmland (Arnaoudov, V. et al. 2015). According to IPCC, smallholder farmers are highly vulnerable to the impacts of climate change due to limited financial resources and increased exposure to extreme weather events (Evangelista et al. 2015).

Despite various government efforts, rice farmers continue to suffer significant losses when faced with climate-related hazards. This highlights the need to identify a refined strategy to minimize the effects and damages from future hazards. The vulnerability index has been identified for targeted intervention and prioritization, serving as a basis or framework for evaluating specific adaptation and input monitoring efforts (Balica et al., 2012; Downing et al., 2005). The estimation of the vulnerability index of rice farmers serves as a critical basis for evidence-informed policymaking aimed at enhancing their resilience to climate change. According to Hoddinott and Quisumbing (2003), most studies on vulnerability assessment utilize econometric approaches such as Vulnerability as Expected Poverty (VEP), Vulnerability as Expected Utility (VEU), and Vulnerability as Uninsured Exposure to Risk (VER). This study also offers an alternative approach to vulnerability assessment by using the probability of ruin to determine the likelihood that a farmer's financial resources, such as capital, assets, or income, will be depleted, which may hinder the continuity of farming operations.

In a developing country like the Philippines, limited physical, financial, and institutional resources pose significant challenges in effectively addressing climate-related challenges (Defiesta and Rapera 2014). Vulnerability assessment offers a robust foundation for identifying suitable adaptation strategies and supports evidence-based planning. Prior studies have assessed the vulnerability of rice farmer households, primarily within a specific local scope (Tran et al. 2022; Ho et al. 2021). This study seeks to examine the vulnerability of rice farmer households at a broader scale and introduces an alternative methodological approach to vulnerability assessment.

Theoretical Framework. In this paper, vulnerability is defined as the likelihood that a farmer will suffer a devastating loss after encountering climate change-related hazards such as heavy rainfall, strong winds, and extreme temperatures. This loss could leave the farmer with extreme difficulty in continuing rice farming, posing significant challenges to their livelihood. Mathematically, VI is defined as

$$VI = P(lr > lr_0)$$

where

VI = Vulnerability index
lr = worst loss ratio
lr_0 = threshold loss ratio

This VI is analogous to the concept of ruin probability in mathematics. The probability of ruin is used in various fields such as insurance and finance (Firouzi et al. 2025). In the actuarial field, the probability of ruin is a measure of the likelihood that an insurance company will become ruined or bankrupt, meaning its capital will drop below zero. The loss ratio is defined as

$$lr = \frac{ny - ws}{ny} = \frac{L}{ny} \quad (1)$$

where:

lr = worst loss ratio
ws = worst harvest due to climate-related hazards (kg)
ny = normal year harvest (kg)
L = highest rice harvest loss experienced due to climate-related hazards (kg)

The worst loss ratio measures the percentage of harvest lost due to unfavorable weather conditions under the worst-case scenario. The threshold loss ratio is the minimum loss ratio that will lead to a devastating loss. The concept of loss ratio originates in the insurance field. It is a key financial metric that represents the percentage of earned premiums an insurer spends on paying claims and other expenses related to claims. It's calculated by dividing the total amount of losses (claims paid, plus adjustment expenses) by the total premiums earned.

MATERIALS AND METHODS

Study sites. The municipalities included in this study were Mangatarem, Pangasinan (Region 1), Solana, Cagayan (Region 2), Minabalac, Bicol (Region 5), Pototan, Iloilo (Region 6), Mahayag, Zamboanga del Sur (Region 9), Malaybalay, Bukidnon (Region 10), and Mlang, Cotabato (Region 12). Data from the Philippine Statistics Authority (PSA 2024) show the regions included in this study collectively contribute approximately 53% of the Philippines' total annual rice output, reflecting their critical importance to national rice production. Within these regions, the selected municipalities represent the top one or two rice-producing areas in their respective provinces. On average, these municipalities account for about 11% of provincial rice production (PhilRice 2024).

Sampling procedure. Multi-stage stratified random sampling was employed in the selection of respondents for this study. Multi-stage stratified random sampling improves representativeness by proportionally including key subgroups, reducing sampling bias and enhancing estimate accuracy (Cochran 1977). Its multi-stage design increases efficiency and feasibility in large, dispersed populations while lowering fieldwork costs and maintaining randomness within strata (Lohr 2022).

The strata were based on the Manila Observatory's classification of provinces according to climate change risk of high, medium, and low. Rice-producing provinces were randomly selected from each stratum, with Regions 2 and 5 classified as high-risk, Regions 2 and 9 as medium-risk, and Regions 6, 10, and 12 as low-risk. A rice-producing municipality was then randomly chosen in each of the provinces. Respondents in the chosen municipality were randomly selected from a list of rice farmers provided by the Municipal Agriculture Office of each local government unit in this survey. If a selected respondent could not be contacted, they were replaced with another randomly chosen sample from the same stratum.

Data collection. A survey of 100 rice farmers was conducted using a structured questionnaire in coordination with the municipal agriculture offices of selected local government units. The relatively small sample size is justified by the use of multi-stage stratified random sampling, which ensured adequate representation across key strata despite the limited number of respondents. As Mooi et al. (2018) stated, the strength of samples comes from selecting samples accurately, rather than their sizes. Moreover, practical constraints such as time, financial resources, and the geographic dispersion of farming communities further limited the feasible sample size, a common challenge in field-based empirical research (Creswell and Creswell 2018; Etikan and Bala 2017).

The structured questionnaire was constructed to obtain information on the socio-demographic characteristics of the farmers, their households, and rice production information. Other questions associated with climatic stress were obtained to determine exposure for the last 10 years (i.e., number of extreme climatic stresses, loss of rice harvest, and worst rice harvest due to climatic stresses). The questionnaire was pretested with five rice farmers in Bay, Laguna, over two sessions to evaluate clarity, relevance, and consistency of responses. Feedback from participants was used to refine questions wording and structure, ensuring the instrument's validity and suitability for the main survey.

Data analysis. A fractional logit regression model was utilized to determine the farmer's loss ratio. Fractional regression is appropriate when the dependent variable is a proportion bounded between 0 and 1, such as indices, in this case loss ratio. It ensures predicted values remain within valid limits and provides consistent estimates, unlike linear regression models that may yield invalid predictions (Papke and Wooldridge 1996). The specification of the model is presented below:

$$ln\left(\frac{lr_i}{1-lr_i}\right) = \beta_0 + \beta_1 gender_i + \beta_2 SFI_i + \beta_3 loan_i + \beta_4 livestock_i + \beta_5 crop\_ins_i + \beta_6 training_i + \beta_7 typhoon_i + \beta_8 dought_i + \beta_9 assist_i + \varepsilon \quad (2)$$

where:

lr_i = worst loss ratio
gender =Dummy;1= male, 0 = otherwise
SFI_i= share of rice farming income to total HH income
$loan_i$= amount of existing loan
$livestock_i$ =Dummy; 1= own livestock, 0 = otherwise
$crop\_ins_i$= Dummy; 1= with crop insurance, 0 = otherwise
$training_i$ = Dummy; 1=attended at least 1 training related to agriculture in the last 10 years, 0 = otherwise
$typhoon_i$ = nbr of typhoons experienced in the last 10 years
$drought_i$ = number of drought events experienced in the last 10 years
$assist_i$ = Dummy; 1= availed government assistance, 0 = otherwise
i = farmer

Various regression models were conducted with different combinations of variables. The regression model chosen was determined based on the goodness of fit of the various fractional regression models as measured by the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The model with the lowest AIC and BIC was chosen. The vulnerability index was then determined using a standard normal approximation for the distribution of the loss ratio.

RESULTS AND DISCUSSION

Profile of the respondents. Table 1 provides an overview of the characteristics of the surveyed rice farmers. It shows that the rice farmer respondents were primarily male, accounting for 85% of the sample size. This indicates that agriculture is still a male-dominated sector. The average age is 54, with the youngest being 23 years of age and the oldest 78 years old. This implies a high proportion of older rice farmers in the country. On average, they have 27 years of farming experience. The mean number of years of education is 11, indicating that most farmers have at least a year of tertiary education.

The mean household size is 4.34, where the minimum is 2 and the maximum is 11. The average share of farm income relative to total household income is 75% as some younger family members choose non-agricultural employment. Additionally, 63% of respondents have outstanding loans, with the mean amount of PhP 75,100. Approximately 41% of the respondents own livestock. On average, the farmer respondents reported experiencing about 23 typhoons and 11 drought events over the past decade. However, only 9% of the respondents have crop insurance, while 93% have access to government assistance and have participated in at least one training course on agriculture.

Table 1. Socio–demographic characteristics of respondents

Variable	Mean	Std. Dev.	Min	Max
Gender	0.85	0.36	0	1
Age	53.66	10.75	23	78
Years of schooling	11.12	2.60	4	17.5
Farming experience	26.83	12.41	3	60
Household size	4.34	1.60	1	11
Farm Size	5.74	13.88	0.4	127
Ownership of farm	0.62	0.488	0	1
Share of rice farming income to total income	74.68	30.50	10.53	100
Loan	75,100	303,404	0	3,000,000
Livestock	0.41	0.49	0	1
Crop insurance	0.09	0.29	0	1
Typhoon	22.87	15.00	6	52
Drought	10.99	7.19	3	30
Training	0.93	0.26	0	1
Access govt program	0.93	0.26	0	1

Regression results. Table 2 displays the regression results for the model that yielded the lowest Akaike Information Criterion (AIC) among the estimated models with various combinations of explanatory variables. The model with the smallest AIC and BIC score is determined to be the better-fit model (Fabozzi et al. 2014). In addition, the model results indicate a good overall fit, with the chi-square test (Prob > χ^2 = 0.0000) showing that the explanatory variables jointly contribute significantly to the model. The pseudo R^2 value of 0.3256 suggests that about 32.6% of the variation in the dependent variable is explained by the predictors, which is acceptable for cross-sectional data (McFadden 1974). The log pseudolikelihood (–35.457) indicates a satisfactory model fit (Greene 2018).

Table 2. Fractional logistic regression results

Variable	Loss Ratio
Gender	-0.812
	(0.509)
Share of rice farming income to total HH income	0.0101**
	(0.00479)
Loan	-7.06e-07***
	(1.10e-07)
Livestock	-0.236
	(0.347)
Crop insurance	1.643**
	(0.746)
Training	-1.600***
	(0.307)
Typhoon	0.0189*
	(0.0114)

Variable	Loss Ratio
Drought	0.383***
	(0.0532)
Access to government assistance	-1.483*
	(0.877)
constant	0.889
	(1.074)
Prob >chi^2	0.0000
Psuedo R^2	0.3256
Log pseudolikelihood	-35.457352
AIC	90.9147
BIC	116.9664

Notes: Standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01"
Source: Author's calculation

Marginal effects of the dependent variable. Table 3 presents the marginal effects, which represent the change in the probability of an outcome resulting from a one-unit change in a predictor variable, while holding other variables constant (Long and Freese 2014). Results show that a 1 percentage point increase in the share of rice farming income to total household income is associated with a 0.10 percentage point increase in the loss ratio. This shows that rice farmer households that rely mainly on rice farming income are more vulnerable to losses. Akhtar et al. (2018) and Khan et al. (2022) state that farmer households with off-farm income have a positive attitude towards implementing new strategies such as new rice varieties and better fertilizer management to improve yield and better resistance to the impact of climate change. This shows that adaptive capacity increases as off-farm income increases. Farmers who depend entirely on farming income are more susceptible to climatic shocks and face significant financial loss.

Loan, on the other hand, has a negative relationship with the loss ratio. The marginal effect of –8.02E–08 ($p < 0.01$) indicates that an increase in loan amount is associated with a small but statistically significant reduction in the loss ratio. This finding is consistent with the results of Adzawla and Baumüller (2020) and Ho et al. (2022). The negative relationship between the loan and the loss ratio of harvest reflects the utilization of the loaned amount to improve resilience and recover from natural hazards (Debesai et al. 2019; Adzawla and Baumüller 2020; Ho et al. 2022). In addition, Khan et al. (2022) noted that access to financial capital, like a loan, can enhance a farmer's adaptive capacity and decision-making.

Farmers with crop insurance exhibited a 119 percentage-point increase in the loss ratio. These results are consistent with the findings of Smith and Goodwin (1996) and Fadhliani et al. (2019), who observed that crop insurance coverage may reduce input use and risk-reducing activities, resulting in lower yield. According to previous studies of Wu et al. (2019) and Clarke and Dercon (2016), this pattern may reflect moral hazard, wherein the security provided by insurance leads farmers to adjust their behavior by lowering farm inputs and reducing investment in risk-mitigation practices. Additionally, the crop losses experienced by other farmers may stem from the choice of the insured farmers to cultivate riskier crops or varieties (Yu and Sumner 2018). In this study, respondents reported that rice production losses were mainly due to typhoons and droughts, yet most did not modify their farming practices. Consequently, the absence of adaptive measures among insured farmers exposed to these hazards likely contributes to higher loss ratios.

There was a positive correlation between climate-related factors, including typhoons and droughts, and loss ratio or damage in rice production. Specifically, each additional typhoon and drought increased the loss ratio by 0.20 and 4.4 percentage points, respectively. Typhoons, characterized by strong winds and heavy rainfall, negatively impacted rice production in the Philippines. Research results of Koide et al. (2012), as cited in Blanc and Strobl (2016), found a negative correlation between typhoons and rice production. Furthermore, a study by Defeista and Mediodia (2016) emphasized the detrimental impact of typhoons and droughts on rice production in the Philippines.

Training and access to government assistance also have a negative relationship with the loss ratio. A unit increase in attendance to training and access to government assistance experienced an 18.6 and 17.2 percentage point decrease in the loss ratio, respectively. The results aligned with those of Issahaku et al. (2022), who also indicated that training rice farmers can improve their yields. Ituriaga et al. (2024) noted that informing farmers about new farming techniques is crucial, as it can significantly enhance their agricultural practices and increase crop yields. Government assistance comes in various forms, including financial assistance, training programs, and the provision of agricultural inputs. Consequently, the effect of government assistance is parallel to that of loans and training. The provision of inputs to production also aligned with the results of studies by Thanapan (2019), Azumah and Zakaria (2019), Nasrin et al. (2018), and Yang et al. (2023). This suggests that government aid helps mitigate agricultural losses.

Table 3. Marginal effects of the dependent variables

Variable	Loss Ratio
Gender	-0.094
	(0.573)
Share of rice farming to total HH income	0.001**
	(0.001)
Loan	-8.02E-08***
	(1.06E-08)
Livestock	-0.027
	(0.040)
Crop insurance	1.191**
	(0.088)
Training	-0.186***
	(0.039)
Typhoons	0.002*
	(0.001)
Drought	0.044***
	(0.005)
Access to government assistance	-0.172*
	(0.102)
Constant	0.889
	(1.074)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Vulnerability of rice farmer households. The vulnerability classification used in this study was adapted from IPCC (2014) and Balica (2012), wherein the original five categories ("very low," "low," "moderate," "high," and "very high") were simplified into low, moderate, and high to better align with the data distribution. This study posits that households with a vulnerability index (VI) of less than or equal to 0.4 are categorized as having low vulnerability, while those with a VI between 0.41 and 0.6 are considered moderately vulnerable, and those with a VI greater than 0.6 are classified as highly vulnerable. The mean vulnerability decreases as the threshold increases (Table 4). The threshold represents the amount of damage that rice farmer households can withstand. The mean vulnerability for each threshold indicates that, on average, the probability of farmers facing ruin after experiencing losses of 50%, 75%, and 90% are 0.82, 0.67, and 0.57, respectively. As expected, the number of instances of low vulnerability increased with a rising threshold, while the opposite is true for households with high vulnerability. In addition, a substantial number of rice farmer households fall into the highly vulnerable category.

Table 4. Descriptive statistics of vulnerable rice farmer households by threshold level

Threshold	VI (All Rice Farmer Households)		
	50%	**75%**	**90%**
Mean	0.82	0.67	0.57
Standard Deviation	0.36	0.43	0.46
Minimum	0.00	0.00	0.00
Maximum	1.00	1.00	1.00
Incidence of Low Vulnerability (%)	15.00	29.00	40.00
Incidence of Moderate Vulnerability (%)	3.00	3.00	1.00
Incidence of High Vulnerability (%)	82.00	68.00	59.00

Characteristics of rice farmer households by vulnerable group and threshold level. Table 5 shows the characteristics of the respondents by vulnerability group using the three thresholds. It shows that the high-vulnerable group has the largest share of rice farming income in total household income compared to the other two groups at all thresholds. This aligns with the findings of Tran et al. (2022) and Ho et al. (2022), which demonstrate that households with alternative sources of income and reduced reliance on farming income lessen their vulnerability. However, the results show that the moderate vulnerability group exhibits the lowest share, while the highly vulnerable group maintains a higher share by a slight difference compared to the low vulnerable group. This probably shows that some other factors affect the vulnerability of the moderate group besides the share of rice farming income to total household income.

The low-vulnerable group had the highest average loan amount of all thresholds. This finding underscores the critical role of access to adequate credit in recovering from climate-induced losses and strengthening farmers' adaptive capacity and resilience. This is consistent with previous studies that reported improved credit access is associated with reduced vulnerability to climate change (Ho et al. 2022; Adzawla et al. 2020; Debesai et al. 2019). Furthermore, the results support the argument that limited access to credit remains a significant constraint to climate adaptation and agricultural development (Ndamani and Watanabe 2015; Adzawla et al. 2020).

The rice farmer households in the low and medium vulnerable groups had no crop insurance across all thresholds. However, 11%, 14%, and 15 % of the high vulnerable group had crop insurance across all thresholds. This shows that farmers with crop insurance were more vulnerable to climate-related hazards than those without crop insurance. Crop insurance may lead to moral hazard, causing farmers to decrease investment in their farms or adopt risk-reducing practices because they feel financially protected (Clarke and Dercon 2016). Reduced investment in farm inputs and risk-reducing practices results in lower yields (Smith and Goodwin 1996; Fadhliani et al. 2019) and decreased rice farming income. However, while the literature identifies several factors contributing to the high vulnerability of insured farmers, respondents indicated that they had not modified their farming practices. Typhoons and droughts were cited as the main causes of rice production losses. As most insured farmers have not adopted adaptive measures and remain highly exposed to these climatic hazards, their loss ratios are likely to increase. This, combined with inaccurate crop damage assessment by the Philippine Crop Insurance Corporation (PCIC) and the delay in claim payouts (Rola and Aragon 2018), can heighten farmers' vulnerability. The program was advantageous for farmers recovering from natural disasters; however, its coverage was insufficient for smallholder farmers (Reyes and Mina et al. 2019). In addition, crop insurance offers immediate financial relief but does not effectively mitigate long-term vulnerabilities to climate-related shocks (Conrado et al. 2017).

On climate-related hazards such as typhoons and droughts, the group with high vulnerability had the highest incidents for both hazards, followed by the moderate and low vulnerability groups. Typhoons can damage rice and reduce harvest. This shows that exposure to climate-related hazards increases rice farmers' vulnerability. Studies have revealed the damage to rice production due to typhoons (Lansigan et al. 2000; Blanc and Strobl 2016), and the positive relationship between drought and vulnerability (Ho et al. 2022), with drought-prone communities being more vulnerable (Manalo et al. 2020)

All rice farmers in the low and moderate vulnerability groups in all thresholds attended successfully training sessions and accessed government assistance. In contrast, only 88% to 91% of rice farmers in the high vulnerability group participated in at least one training course, while 88% to 92% accessed government support. Access to government assistance can offer farmers essential training and financial support, enabling them to recover from damage to their rice farms, particularly in the face of climate-related hazards. The provision of training to farmer households is a crucial factor that can enhance their ability to reduce vulnerability (Tran et al. 2022).

The group identified as highly vulnerable exhibited the most significant percentage share of income derived from farming, albeit by a marginal difference compared to the low vulnerability group. Furthermore, this highly vulnerable group possessed the lowest total amount of loans among the three groups analyzed; however, the average loan amount constitutes the highest percentage share of their income. Additionally, it is noteworthy that the highly vulnerable group was the only cohort with the lowest percentage of respondents who participated in agricultural training and had access to government assistance compared to the other two groups.

Table 5. Characteristics of rice farmer households by vulnerability and threshold level

Variable	Threshold	Vulnerability		
		Low	Moderate	High
Share of rice farming to total HH income (%)	50	70.93	73.95	75.40
	75	75.73	37.76	75.86
	90	71.63	40.00	77.16

Variable	Threshold	Vulnerability		
		Low	**Moderate**	**High**
Loan (Php)	50	224,533	23,333	49,659
	75	129,103	66,667	56,034
	90	106,026	50,000	52,881
Crop ins (%)	50	0	0	11
	75	0	0	14
	90	0	0	15
Attended Training (%)	50	100	100	91
	75	100	100	88
	90	100	100	88
Typhoon	50	13.20	30.33	24.37
	75	17.10	22.33	23.75
	90	18.74	20.00	25.80
Drought	50	4.20	4.67	12.46
	75	4.93	8.00	11.58
	90	5.44	9.00	14.73
Access to Government (%)	50	100	100	91
	75	100	100	92
	90	100	100	88

Characteristics of respondents with high vulnerability. The results revealed that rice farmers, classified as highly vulnerable, were respondents with a significant proportion of their income derived from rice farming. In addition, the group with high vulnerability was the only group with farmers who had crop insurance coverage. As insured farmers frequently experience typhoons and droughts, but have not implemented adaptive measures.

Among the three groups, the group with the highest vulnerability was the most exposed to natural disasters, particularly typhoons and droughts, followed by the moderately vulnerable group. Further disaggregation of the data revealed that respondents with high vulnerability had endured more instances of rice farm flooding and flood damage. Furthermore, the high-vulnerability group experienced an average maximum crop loss of 94% due to climate-related hazards across thresholds, and the low and moderate vulnerability groups suffered average losses of 49% and 56%, respectively. Moreover, the group with high vulnerability was the only cohort with the lowest percentage of respondents who participated in agricultural training programs and had limited access to government assistance.

In addition, the group with high vulnerability consists of 47% of rice farmers who lived in the area classified by Manila Observatory as low-risk provinces, and 29% and 23% live in the medium and high-risk provinces, respectively. This supports the assertion by IPCC 2014 that vulnerability is not solely driven by a single factor, such as climate-related hazards, but by a combination of concepts and elements, including exposure to hazards, sensitivity, and adaptive capacity.

CONCLUSION

This study demonstrated an alternative approach to assessing the vulnerability of rice farmers. By using the concepts of probability of ruin and worst loss ratio, the study identified the factors that affect farmers' vulnerability and determined their vulnerability index.

The share of farming income to total household income, crop insurance coverage, exposure to hazards such as typhoons and droughts, insufficient training in rice farming and agriculture, and limited access to government assistance programs contributed significantly to the vulnerability of rice farmers. Furthermore, while crop insurance is anticipated to mitigate farmers' vulnerability, issues such as limited coverage and operational inefficiencies must be addressed. In addition, the results also show that the group with high vulnerability has the lowest percentage of respondents who have participated in agricultural training programs and have limited access to government assistance. The vulnerability index developed for rice farmers offers critical evidence-based information for designing targeted and informed climate adaptation policies. Building on this, further research should examine the specific variables that contribute to vulnerability to refine intervention strategies. Moreover, accurately identifying the farmers' training needs and the appropriate forms of assistance can significantly enhance their capacity to adapt and reduce overall vulnerability to climate-related risks.

To strengthen the resilience of rice farmers, policies should promote balanced livelihood diversification supported by targeted training and capacity-building programs that equip farmers with the skills to engage in profitable off-farm and value-adding activities without compromising farm productivity. Training modules should integrate climate risk management, sustainable water use, and crop diversification strategies to enhance both income stability and adaptive capacity. Furthermore, improving access to government assistance through digitalized platforms and transparent targeting can ensure that support reaches farmers in the most climate-vulnerable areas in a timely and equitable manner.

Enhancing credit access via simplified loan procedures and cooperative-based financing will enable farmers to invest in adaptive technologies. Likewise, the crop insurance program should be rationalized and simplified to enhance administrative efficiency and promote broader farmer participation through more accessible enrollment and claims procedures. In addition, implementing comprehensive awareness and information campaigns can increase farmers' understanding of insurance benefits and procedures. Expanding coverage and strengthening protection against climate-induced shocks would further enhance the program's effectiveness as a risk management tool.

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