THE LEVEL AND DRIVERS OF CROP DIVERSIFICATION IN RICE-BASED FARMS: EVIDENCE FROM THE TOP THREE CROP-DIVERSIFYING LUZON PROVINCES OF THE PHILIPPINES

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ABSTRACT

Crop diversification has been recognized as a resiliency measure against challenges like climate change. However, only a few rice farmers in the Philippines have adopted this despite its established benefits. This paper tried to uncover the reasons for the farmers' choice using 2021 survey data from 109 crop-diversifiers and 108 purely rice farmers from the top three crop-diversifying provinces in Luzon. It estimated the diversification levels, compared the profiles of monocroppers and crop-diversifiers, and determined the factors affecting farmers' choice of a cropping system. Descriptive analysis and t-test of means between crop diversifiers and monocroppers were performed. The Simpson Diversification Index (SDI) was used to measure the degree of crop diversification in farms. Since SDI has values ranging from 0 to 1, Tobit regression analysis was used to determine the factors affecting crop diversification level. The largest parcels for both monocropped and diversified farms were used as reference units in all analyses. Results revealed that majority of crop diversifiers had SDI of 0.50 and below; the majority (91%) employed a relay cropping system; and that net income from crop production increased as the diversification level increased. Farming experience, non-rice related training, soil texture, topography, irrigation source, distance between the farm and the nearest market and distance of farm to concrete road structure emerged as significant factors shaping the farmers' decision regarding their cropping systems. Despite increased net income, both farmer groups are still challenged by inadequate capital assistance, machinery, postharvest and irrigation facilities, technical guidance, area suitability, and water supply problems. Corresponding recommendations were provided to help mainstream rice-based crop diversification.

Key words: Simpson Diversification Index, Tobit regression

INTRODUCTION

Crop diversification (CD) can follow either the horizontal or vertical approach (Kaur and Malhi 2021; Paroda 2022). The horizontal approach involves adding new crops to the single-crop production system using multiple cropping techniques. Vertical diversification, on the other hand, involves the processing of any crop into other forms. These two approaches can both result in economic gains. However, this paper focuses only on horizontal diversification.

CD is a widely accepted means of managing the impacts of climate change and economic-factor fluctuations on farmers' harvest and income. It helps increase productivity and stabilize income of smallholders by broadening the crop portfolio and income sources (Barman et al. 2022; Ignaciuk et al. 2018; Kaur and Malhi 2021; Khanam et al. 2018; Paroda 2022; Walia 2020). This reduces farmers' risks to weather and market changes. Moreover, it increases net returns from crops and per unit of labor, optimizes use of land and other resources, and increases job opportunities (Barman et al. 2022; Kaur and Malhi 2021; Walia 2020).

CD promotes resilience in agriculture. It inhibits the occurrence of pest outbreak, prevents pathogen transmission, and helps secure food supply to mitigate the effects of climate variability and extreme weather changes to crop production (Barman et al. 2022; Walia 2020). In fact, CD was highly observed in drought-risk areas, where effects of climate variability is more severe (Ignaciuk et al. 2017). In the Philippines, planting cash crops is usually performed during the dry season (October to May) after planting rice as their main crop (Corales and Corales 2019).

The Philippine rice industry is currently facing many challenges. These include domestic supply, importation issues, export bans, high fertilizer and fuel prices, and climate change (Baclig 2022; Esguerra 2024; Glauber and Mamun 2023a; Glauber and Mamun 2023b; Kee et al. 2023; PCO 2023). These challenges have resulted in increased rice prices and escalated production costs, production losses, among others (Glauber and Mamun 2023a; Glauber and Mamun 2023b; Gomez 2024; Kee et al. 2023; Valera et al. 2024). Under these circumstances, CD is one of the strategies that farmers could adopt to cope with these challenges affecting their income (Bugayong 2021; Cabardo 2022; Sevillano 2022).

However, despite the recognition of CD's benefits to farmers, very few of them are CD practitioners. Based on the Rice-based Farm Household Survey (RBFHS) data of the Philippine Rice Research Institute (PhilRice) covering 2016-2017 cropping seasons (Table 1), only 8 percent of farm households in 2016 and 7 percent in 2017 practiced CD.

Table 1. Distribution of farmers by cropping system in 42 major rice producing provinces, Philippines, WS2016 and DS2017

Cropping System	2016 Wet Season		2017 Dry Season	
	No.	%	No.	%
Monocropping (rice only)	2,892	92	2,889	93
Diversified cropping	264	8	210	7

This paper tried to explain the observed decisions of rice farmers regarding diversification of their farms. Understanding the adoption barriers will help the government craft appropriate interventions to enhance adoption. Specifically, it estimated the diversification level of the reference farms; profiled and compared rice monocroppers and crop-diversifiers and their farms; identified the factors that could influence a farmer's decision to crop-diversify; and documented the farmers' experience and perceptions about CD.

Few socioeconomic studies have evaluated CD adoption of rice farmers in the Philippines. Farmers' age, education, tribe, man and man-animal labor were the significant factors that had specifically affected the CD level of upland rice farmers in Trento, Agusan del Sur in the Philippines (Deriada and

Doloriel 2022). Meanwhile, farmers were more intuitive in their decision to pursue CD (de Leon and Manalo 2024). Their decision-making process begins with a rational evaluation of the affordances, such as potential benefits and risks, but the final choice is based on farmers' intuition, grounded on rich experiences. Other literature discussed policy issues related to CD (Adriano et al. 1989; Briones 2009; Espino and Atienza 2001; Gonzales 1987; Gonzales-Intal and Valera 1989) but may already need updating. This research paper can provide more updated information about CD, which is hoped to aid in crafting interventions tailored to the current conditions of the country's rice farmers.

MATERIALS AND METHODS

Based on the available RBFHS dataset (Wet Season 2016 and Dry Season 2017), the top crop-diversifying provinces were mostly in Luzon (Fig. 1). Hence, the selection of study sites focused on the island where the top three provinces where rice farmers practicing crop diversification were selected. Random selection was employed to identify a municipality in each of these provinces and four barangays from each municipality. The study sites were Tubburan, Cabusligan, Bani, and Pulangi in Bacarra, Ilocos Norte; Banaoang West, San Roque, Sta. Monica, and Sta. Lucia in Moncada, Tarlac; and Cabubulaunan, Pantoc-Bulac, Bulac, and Valle in Talavera, Nueva Ecija.

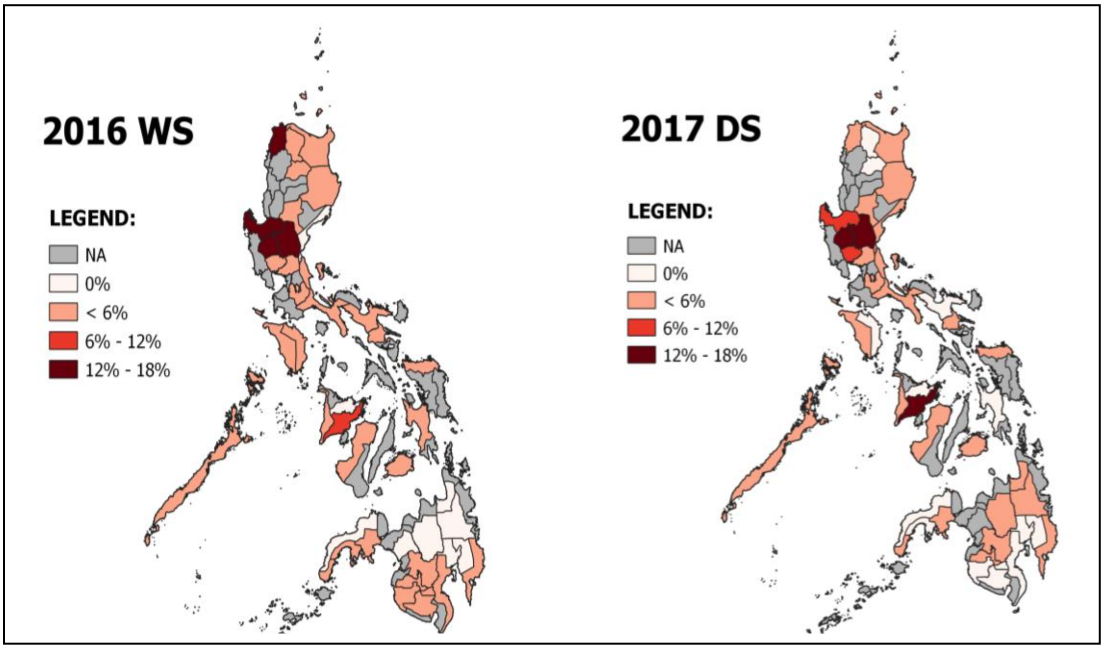

Figure 1. Distribution of farmers who practiced crop diversification, Wet Season 2016 and Dry Season 2017

A total of 109 crop-diversifying and 108 purely rice farmers were selected for the survey covering the 2021 cropping seasons. Per municipality, at least 36 CD farmers and 36 monocroppers were selected to satisfy the prescribed sample size of 30 or more based on the Central Limit Theorem. Random sampling was used in selecting 72 farmer-respondents from Bacarra, Ilocos Norte and 73 from Moncada, Tarlac. The researchers utilized a master list of rice farmers provided by the Municipal Agriculture Office (MAO) from where the randomly selected farmers were drawn. For Talavera, Nueva Ecija, however, the researchers had to resort to convenience sampling because the assigned coordinating staffer from the local government unit had difficulty in convening the farmers included in the provided list of randomly selected farmers. Hence, the farmers who were available during the survey period were interviewed instead.

In this study, the farmers classified as crop-diversifiers are those who cultivated at least one parcel where rice is either intercropped or relayed with other crops, while monocropping farmers are those who had all of their parcels planted with rice only in all cropping seasons.

The reference parcel in this study refers to the largest rice farm cultivated by monocroppers, and the largest diversified farms by crop diversifiers. The production data and farm profile in this study were based on these reference parcels.

Descriptive statistics were used to describe and compare crop-diversifying and monocropping farmers and their fields. The significance of mean differences in each of these variables was determined using a T-test.

A popular measure of CD level, *i.e.*, the Simpson Diversification Index (SDI), was used in determining the CD level of farms because of its simplicity. It has also been used in many literatures (Gebiso et al. 2023; Mzyece et al. 2023; Saha and Bahal 2014). It uses the equation below:

$$SDI = 1 - \sum_{i=1}^{n} P_i^2 \quad (1)$$

Where P_i is the proportion of the area devoted for the ith crop to the total cropping area. SDI has a value ranging from 0 to 1. As the value moves closer to zero, the more specialized the production. Crop production is more diversified when the index approaches one (Makate et al. 2023; Sichoongwe et al. 2014).

The SDI was regressed against a set of explanatory variables to identify the significant factors influencing the CD level. Since SDI is a censored variable, it has to be estimated using Tobit regression, a censored regression model that has the power to estimate the latent regressand using the available information of the regressors. It can be expressed as:

$$y_i^* = \beta X_i + \mu_i \quad (2)$$

Where: $y_i = y_i^*$ if $y_i^* > 0$

$y_i = 0$ if $y_i^* \leq 0$

y_i is the dependent variable, β is the vector of coefficients, X_i is the vector of independent variables, and μ_i is the error term assumed to be independent and normally distributed with mean 0 and constant variance (Amemiya 1984; McDonald and Moffit 1980).

Based on this expression, an initial model was developed with SDI as the dependent variable y_i, and socio-demographic, land features, and market-related variables as the explanatory variables X_i. This set of variables was hypothesized to influence a farmer's decision to implement a technology, as found in some literature (Ashfaq et al. 2008; Gebiso et al. 2023; Mariano et al. 2012; Nor Diana et al. 2024; Sichoongwe et al. 2014). The sociodemographic variables considered were sex, age, civil status, education (i.e., number of years spent in school), farm experience (in number of years), household size, membership to farmers' organizations, and attendance to relevant training/seminars. Meanwhile, land characteristics considered were the number of rice-based parcels, topography or terrain of the reference parcel, major road structure, physical area of the parcel in hectares, soil texture, distance of the farm to major road in kilometers, distance between the farm and the market in kilometers, and water irrigation source.

The model, however, was reduced to nine explanatory variables after subjecting it to a variable selection procedure, i.e., the Backward Stepwise Regression, wherein variables were assessed at 5% p-value. The final explanatory variables are summarized in Table 2 with their corresponding expected signs of coefficients.

Table 2. The explanatory variables included in the model and the expected signs of their coefficient.

Explanatory Variables	Description	Expected Sign
Farming experience	Number of years of farming experience (regardless of crops planted)	+
Attendance to non-rice related training	Dummy variable with a value of 1 if the farmer was able to attend a non-rice related training	+
Soil Texture	Dummy variable with a value of 1 if the land is a non-clayey soil; 0 if clayey.	+
Farm Topography	Dummy variable with a value of 1 if the land is elevated/hilly; 0 otherwise.	+
Farm-to-market distance	Distance of the farm from the nearest major market in the locality (in kilometers)	+/-
Distance of farm from concrete road structure	Distance of the farm from the nearest concrete road in the locality (in kilometers)	-
Irrigation Source 1	Used rain in one or both seasons as source of irrigation.	+
Irrigation Source 2	Used mixed of SSIS/natural source and NIS within the reference year.	+
Irrigation Source 3	Used purely SSIS/natural source of irrigation water within the reference year	+

Notes: NIS/CIS - national/communal irrigation system
SSIS - small scale irrigation system

Farming experience and attendance to relevant training (i.e., non-rice) were expected to positively influence the SDI as these are skill-related variables that can aid in farmers' understanding of the intricacy of and implementing production of more than one crop in the same field.

Land features such as soil texture, topography, and irrigation water source determine the type of crops that can be suitably grown in an area, hence, is hypothesized to influence the level of diversification (Bhat et al. 2023; Buisson and Balasubramanya 2019; Cablayan and Pascual 1989; Catudan et al. 2019; Corales et al. 2019; Maglinao et al. 1993; Varsha et al. 2020). The soil and topography dummy variables were expected to have a positive coefficient. Meanwhile, the combined WS-DS irrigation water source was considered instead of using separate dummies for each season because the dependent variable, SDI, was also measured based on the annual cropping pattern of the farmers. The following categorization was implemented: (a) purely sourced from large-scale irrigation system, i.e., NIS/CIS, in both seasons (b) water sourced from rain in at least one season (i.e., NIS/SSIS in the DS and rain in the WS or rain in both seasons); (c) mixed sources from small and large-scale irrigation systems within the production year; and (d) purely sourced from small-scale irrigation system, i.e., SSIS in both seasons. The first category was the base variable, while the remaining three were explicitly shown in the model. The three irrigation variables were expected to have higher SDI than the base variable, because diversification is a risk-mitigating strategy against production problems like water scarcity.

Market-related infrastructures were also considered in the model. Farm-to-market distance can either have a positive or negative influence on SDI. A positive coefficient indicates that farms farther from the major market is more diversified because farming households in remote areas need a cheaper means of accessing varied food choices. On one hand, a negative value means that farms closer to a market has greater trading opportunity for their perishable crops (Bernzen et al. 2023; Gebiso et al. 2023; Sichoongwe et al. 2014). The distance of the farm from a concrete road can also influence SDI, with a negative expected coefficient. Farms may be more diversified if good road structure is more accessible, thus, marketing of produce is easier.

The explanatory variables were examined for multicollinearity using the Variance Inflation Factor (VIF). A VIF greater than or equal to 5 suggests that explanatory variables are highly correlated with each other (Shrestha 2020). If the variables are highly collinear, then it will be difficult to isolate each X's influence on the regressand (Gujarati and Porter 2009; Shrestha 2020; Sichoongwe et al. 2014). Table 3 shows that the mean VIF of the set of regressors is 1.18 (Table 3). There is also no indication of high collinearity among individual variables. Therefore, the model passed the multicollinearity test.

Table 3. Variance inflation factors of the explanatory variables.

Variables	VIF
Irrigation source 1	1.46
Irrigation source 2	1.13
Irrigation source 3	1.44
Farming experience	1.02
Non-rice related training	1.08
Soil texture	1.09
Topography	1.13
Distance of the farm from the concrete road	1.07
Farm-to-market distance	1.18
Mean VIF	1.18

The model specification, moreover, yielded the smallest Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values among the other developed models for the study, indicating the best fit model for the data. AIC and BIC are measurements used in evaluating competing models (Burnham and Anderson 2004; Dziak et al. 2020; Fabozzi et al. 2014; Su and Mwanakatwe 2020).

Finally, using open-ended questions, information on farmers' experience and perceptions were gathered. These were used to explain other factors influencing a farmer's choice whether to crop-diversify or specialize, which were not captured by the regression model.

RESULTS AND DISCUSSION

Farmers' profile. The majority of the 109 farmer-respondents (91%) who practiced CD employed a relay cropping system, which involves sequential planting of different crops in the same field, optimizing space and resource utilization (Fig. 2).

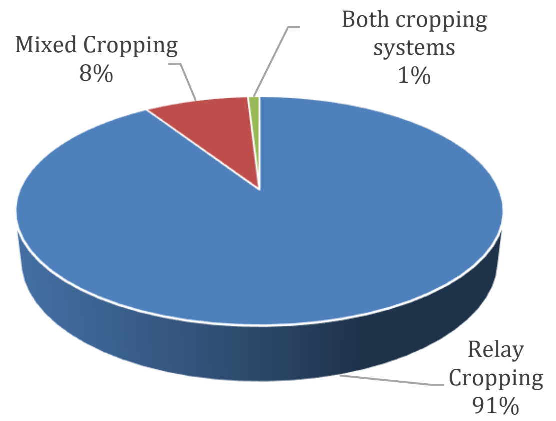

Figure 2. Distribution of farmer-respondents by type of diversified cropping system, cropping seasons of 2021.

In contrast, eight percent of the farmers preferred mixed cropping that entails cultivating two or more different crops simultaneously in a given area, promoting biodiversity and reducing the risk of crop failure. Only one percent of them utilized both relay and mixed cropping systems, showcasing a hybrid approach to crop diversification. This highlights the prevalence of specific cropping systems and also the varied strategies adopted by farmers to enhance agricultural sustainability and productivity.

Monocropping and crop-diversifying farmers had almost the same profile, except on knowledge- and skill-related variables (*i.e.*, education, farm experience, and attendance to training) (Table 4). This could imply that practicing CD entails greater skills and knowledge because it involves the production of different crops. Surprisingly, there were 19 percent of monocropping farmers who had also participated in non-rice crop-related training, suggesting a potential latent interest or evolving perspectives within this group. The t-test result underscores the role of knowledge acquisition in motivating farmers to diversify their agricultural pursuits.

Table 4. Sociodemographic profile of 217 farmers by cropping system, selected areas, Luzon, Philippines, 2021 cropping season

Sociodemographic Variables	Monocropping n=108	Diversified Cropping n=109
Mean age (years)	55	56
Sex (% male)	72	64
Civil status (% married)	77	78

Sociodemographic Variables	Monocropping n=108	Diversified Cropping n=109
No. of years in schooling *	9	10
Farming experience (no. of years)*	29	32
Average household size	4	4
Attendance in non-rice related training/seminar (% farmers)**	19	41
Membership in organization (% farmers)	98	99
Land ownership (%)	44	52

*Note: ** -significant at 1% level,* significant at 5% level*

The average net income of farmers in 2021 by cropping system for rice and non-rice farms is summarized in Table 5 . Crop-diversifiers received a total net income of PhP183,940 per hectare (ha), which is five times more than that of the rice-monocroppers in 2021. Income from non-rice crops constituted 82 percent of the diversifiers' total net income from crops, amounting to PhP151,217 per ha. The common non-rice crops planted by the farmer-respondents were corn and garlic in Ilocos Norte, onion in Nueva Ecija, and corn in Tarlac.

Table 5. Average net income of 217 farmers by cropping system, selected areas, Luzon, Philippines, 2021 cropping seasons.

Income Source	Monocropping	Diversified Cropping
Rice (PhP/ha)	29,067	32,723
Non-rice (PhP/ha)	n/a	151,217
Total Income (PhP/ha)	29,067	183,940

Farm profile. Table 6 shows the land characteristics of the reference parcels. Crop-diversified farms were more dependent on small-scale irrigation system, rain, or natural source of water. On one hand, majority of rice monocropped farms depended on large-scale irrigation system because rice is a water-loving plant. Consequently, monocroppers experienced water sufficiency in both seasons, while majority of their diversifying counterpart experienced this only when rainfall is abundant. This suggests that farms with access to a reliable or stable water source are more likely to be devoted to pure rice farming, while those experiencing water insufficiency during DS are more likely to crop-diversify as a strategic response. This supports the notion that CD could be an option for climate change adaptation and resilience.

Majority of rice monocroppers (68%) had clayey soil type, while diverse soil types for their counterpart (*i.e.*, majority of crop-diversifiers had loamy, silty, and sandy soil variants). Rice fields were relatively near the market (6.28 kilometers (km)) as compared with crop-diversified farms (7.88 km) (Table 6).

Table 6. Profile of the reference parcel by cropping system, selected areas, Luzon, Philippines, 2021 cropping season

Land Characteristics	Monocrop (n=108)	Diversified (n=109)
Physical Area (ha)	0.98	0.88
Actual area cultivated with rice (ha) **	0.92	0.52
Soil texture (% of farms)		
clayey/silty-clay/clay-loam/clay-sand**	68	39
loamy/silty/silt-loam**	26	50
sandy/sandy-loam/silty-sand	6	12
Actual source of irrigation in the DS (% of farms)		
NIS/CIS**	64	46
SSIS/Natural**	36	54
Rain	-	-
Actual source of irrigation in the WS (% of farms)		
NIS/CIS**	64	48
SSIS/Natural	34	28
Rain**	2	25
Water availability – DS (% sufficient)	75	57
Water availability – WS (% sufficient)	69	74
Farm-major road distance (km)	0.2	0.17
Farm-market distance (km)*	6.28	7.88
Concrete as the major road structure (% farms)	94	91

*Note: **significant at 1% level, * significant at 5% level*

Crop diversification level. The majority of the farmer-respondents who diversified their production had a diversification index of 0.50 and below (Table 7). On average, the CD index of the reference crop-diversified parcels in the top three crop-diversifying Luzon provinces was at 0.55, which is a moderate CD level. It is also interesting to emphasize that the total net income from crop production also increases as the diversification index increases. On top of this, some literature (Barman et al. 2022; Walia 2020) say that CD can result in agronomic benefits, such as a break in pests and diseases cycle, improves soil health as it increases microbes in the soil, thus, better harvest.

Table 7. Distribution of 109 crop-diversifiers and their total net income, selected areas, Luzon, Philippines, 2021.

Index Range	Frequency	Ave. Simpson Index	Total Net Income from Crop Production (PhP/ha)
<=0.50	68	0.49	57,782
>0.50 but <=0.65	16	0.60	107,964
>0.65	25	0.67	247,691
Total/Average	109	0.55	108,706

Factors that influence the crop diversification level. The likelihood ratio chi-square of the Tobit regression model has a p-value of less than one percent, implying a better fit than an empty model (Table 8). The AIC and BIC as discussed in an earlier section, have shown that the model specification has a better fit than the other competing models. Farming experience, non-rice related training, soil texture, topography, distance of farm to the nearest market and to concrete road structure emerged as significant factors in shaping the farmers' decision regarding their cropping systems.

Table 8. Tobit regression results showing the factors affecting the crop diversification level, selected areas, Luzon, Philippines, 2021 cropping seasons.

Variables	Coefficient		Std. Error
Farm experience	0.0086	**	0.0027
Attendance in non-rice related training	0.1517	*	0.0753
Soil Type (1=nonclayey; 0 clayey)	0.2465	**	0.0742
Topography (1=slopy/hilly; 0 otherwise)	0.2961	**	0.1095
Distance to the nearest market (in km)	0.0468	**	0.0140
Distance to major road (in km)	-0.4032	**	0.1247
Irrigation source 1 (1=rain in one or both seasons)	0.3276	**	0.1041
Irrigation source 2 (1=combination of NIS and SSIS)	0.4895	**	0.1500
Irrigation source 3 (1= SSIS in both seasons)	-0.0939		0.0881
Constant	-0.5815	**	0.1432
No. of observations	145		
LR Chi^2 (9)	73.67		
Prob>chi^2	0.0000		
Pseudo R^2	0.3413		
Log likelihood	-71.091		

*Note: **- significant at 1% level, *- significant at 5% level*

Farm experience. The highly significant and positive coefficient for this variable connotes that the expected CD level increases by 0.0086 for every year added to the farmers' experience. Growing more than one crop profitably could be a complex task for a farmer. Rice production alone requires a balanced management of the different production areas (*i.e.*, choosing a variety, land preparation, crop establishment, nutrient, water, pest, harvest, and postharvest management). Adding more crops into the system requires understanding the interaction of the crops, and their implications on aspects such as pest, nutrient, and water management. More experienced farmers can better appreciate such complexities and can easily understand the innovations and strategies involved in diversified farming. Some publications also observed a similar relationship between crop diversification and farm experience (Ashfaq et al. 2008; Grilli et al. 2024; Islam et al. 2024; Nahar et al. 2024).

Topography. The positive coefficient for the dummy variable of hilly/slopy areas implies that the expected CD level is higher by 0.30 units than in non-slopy areas. Lowland farms may be less likely to be used for CD because these are water-endowed, hence, suited to water-tolerant crops, like rice. Other crops, such as corn, are more suitably planted in somewhat dry soil (Sideman 2016). Islam et al. (2024) obtained similar results wherein high and medium high lands had higher chances of being diversified.

Attendance at non-rice related seminars/trainings. Farmers' participation in such seminars/training could result in a 0.15 increase in CD level estimates. This implies that participants to such training are more inclined to implement crop diversification. This is similar to the results of other studies that used some extension-related variables such as the number of extensionists' visits and communication with farmer groups. They obtained a significant and positive coefficient (Bellon et al. 2020; Ibrahim 2009; Islam et al. 2024; Kasem and Thapa 2011; Mesfin et al. 2011; Nahar et al. 2024).

Soil texture. Suitability of land is a highly significant factor in the farmers' choice of production system. Results show that farmers cultivating non-clayey soils had a higher estimated CD level by 0.25 than those with clayey soil types. Clayey soils are heavy and have more water retention capacity, hence are suitable for plants requiring high soil moisture, such as rice. Meanwhile, most vegetables and root crops are best grown in loamy or sandy soils (Tababa 2023). This result is consistent with those in other literatures (Burchfield and de la Poterie 2018; Kasem and Thapa 2011; Kumar and Singh 2012).

Distance between farm and the nearest major market. Results show that for every kilometer increase in farm-to-market distance could result in 0.05-unit increase in the predicted CD level of farmers. This means that farms located farther from the market may be more likely be devoted to CD. This could be a coping strategy of rice farming households in the study sites to access diversified food without incurring high transportation costs. Nevertheless, a better road structure can open up opportunities to market the produce. This result is aligned with the results of other studies that were conducted in other countries (Bellon et al. 2020; Nahar et al. 2024; Sichoongwe et al, 2014).

Distance between the farm and major road. Every kilometer added to the farm-to-road distance can reduce the estimated CD level by 0.40 units. This suggests that farmers cultivating a farm farther from a main concrete/asphalt road are diversifying less. Good transportation infrastructure helps preserve the quality of perishable produce, such as vegetables. Thus, a farm's proximity to concrete roads emerged as a consideration for farmers in pursuing CD. This result is consistent with that of Ashfaq et al. (2008).

Source of irrigation water. Irrigation sources 1 and 2 resulted in significant and positive coefficients. Meanwhile, farmers who sourced their irrigation water purely from SSIS/natural (Source 3) resulted in an insignificant coefficient. The CD level of farmers who accessed water from Sources 1 and 2 was higher by 0.33 and 0.49 units, respectively, than those who had access to a large-scale irrigation system in both seasons. Source 1 refers to sourcing irrigation water from rain in one or both seasons. Farmers who used Source 2 were those who accessed both large- and small-scale irrigation systems within the reference year. Peddi and Reddy (2023) observed similar results for Telangana farmers in India, wherein those who sourced irrigation water from surface water are less likely to diversify than rainfed farmers.

Rice and non-rice crops differ in water requirement. The majority of rice is best grown in flooded areas, which are usually irrigated continuously by a large-scale irrigation system, while non-rice crops are on moderately wet to dry soil conditions. Irrigation systems that are intended for rice production (e.g., NIS/CIS) may need to have a water flow control system to allow the production of other crops (FAO 2003).

Farmers' experiences and perceptions. Farmer-respondents practiced CD mainly to gain higher income (65% of CD farmers) and to optimize land use (28% of CD farmers) (Table 9). This group of sample farmers has been practicing CD for an average of 24 years as of survey time.

Despite their commitment to diversify, only 37 percent of them received production support, and only 10 percent received marketing support from the government. When provided, these production support services were mainly on input subsidies, like seeds and fertilizer, while marketing support is in the form of market linkage (Table 9).

Table 9. Crop-diversifiers' experiences and perceptions on crop diversification, selected areas, Luzon, Philippines, 2021

Items	**Frequency** (n=109)	**Percent of Farmers (%)**
*Top 3 reasons for practicing crop diversification**		
Increase in income	71	65
Optimize use of land	30	28
Source of food	5	5
*Non-rice production support services received**		
None	69	63
Free seeds	19	17
Subsidized fertilizer	15	14
Cash/credit assistance	9	8
Crop Insurance	8	7
Others (technical assistance, free pesticides)	2	2
*Non-rice marketing support services received**		
None	98	90
Link to big buyers	8	7.33
Others (training, postharvest facilities, credit assistance, price support)	4	3.66
*Top 5 factors that farmers think can help sustain their practice of CD**		
Credit/financial/capital assistance	53	49
Free inputs/low input price	29	27
Technical assistance/training	25	23
Link to big buyers/direct buyer	22	20
Irrigation infrastructure	21	19

*-with multiple responses

Crop diversifiers expressed other needs such as capital assistance, machinery, postharvest and irrigation facilities, technical guidance or training, and means to receive higher prices for their produce.

The production cost of crop-diversifiers (PhP113,980 per ha for DS and PhP135,424 per ha for WS) was greater than monocroppers (PhP80,789 per ha for DS and PhP69,121 per ha for WS) (Table 10**)**. Given the high capital requirement associated with CD, nearly half of the 109 crop diversifiers (49%) emphasized the importance of financial assistance that could help sustain and expand their diversification efforts.

Table 10. Capital investment of 217 farmer-respondents per cropping season, 2021.

Cropping System	Dry Season (PhP/ha)	Wet Season (PhP/ha)
Monocropping	80,789	69,121
Crop diversification	113,980	135,424

Other factors that could entice farmers to sustain CD adoption are the provision of subsidized inputs (27%), technical guidance (23%), market linkage (20%), and the presence of irrigation facilities (19%) (Table 11). On one hand, 38 percent of the 108 rice monocroppers reasoned that their field is not suitable for non-rice crop production, 9 percent had a water supply problem, and 8 percent lacked knowledge on producing and marketing these crops; hence, did not pursue CD (Table 11). This supports the significant coefficient of soil texture and farm experience in the Tobit regression results.

Table 11. Monocroppers' experience and perception on crop diversification, selected areas, Luzon, Philippines, 2021.

Items	**Frequency** n=108	**Percent of Farmers (%)**
No. of farmers who diversified cropping system in the past	34	31
Top 3 reasons for not practicing crop diversification[a]		
Land suitability to non-rice production	41	38
Insufficient water supply/irrigation infrastructure	10	9
Lack of technical knowledge	9	8
*Top 3 reasons for discontinued practice of CD (n=34)**		
Large capital investment/high cost of inputs	13	38
Low price of the commodity	9	26
Land suitability to non-rice production	4	12
Top 5 factors that can possibly encourage farmers to practice CD *		
Free seeds	42	39
Subsidized fertilizer	28	26
Credit/capital/financial assistance	26	24
Technical assistance/training	19	18
Fixed/higher price of the commodity	16	15

* - with multiple responses

It is also worth mentioning that rice monocroppers became aware of CD mainly through the information shared by co-farmers and cooperatives (Table 12). This may imply that government-led promotion of CD is limited in the study sites.

Thirty-one per cent of the rice monocroppers attempted to crop-diversify in the past to gain more income but halted mainly due to high capital investment and low selling price of the commodity (Table 11). Nevertheless, 68 percent of respondents expressed interest in future diversification because of the prospect of additional income. The rest were uninterested in pursuing CD in the future, mainly because of the unsuitability of their land and high production costs/lack of capital.

Monocroppers opined that they may be enticed to pursue CD if subsidized production inputs, particularly seeds and fertilizer, are provided. Credit/capital/financial assistance proves to be a significant motivator also for diversification among farmers, highlighting the interconnected nature of support services in fostering crop diversification.

Table 12. Sources of information about crop diversification by monocroppers, selected sites, Luzon, Philippines, 2021

Sources	Frequency[a] n=33	Percent of Farmers
Co-farmers	23	74
Cooperatives	6	19
LGU	3	10
DA-RFU	3	10
Seed/chemical companies	3	10

[a] Of the 108 monocroppers, only 33 were aware of crop diversification

CONCLUSION AND RECOMMENDATIONS

Filipino rice farmers have always been urged to remain resilient amidst the challenges, such as climate change and rising input prices, that confront them. CD is one of the ways that could help farmers adapt to the current situation of the rice industry. Its benefits, however, are enjoyed by few rice farmers only; it has not been widely adopted by farmers.

Farmer-adopters from the top three crop-diversifying Luzon provinces had parcels that can be classified as moderately diversified. Moreover, their total net income from crop production increased as their diversification level increased. Farmers, therefore, should be encouraged to sustain crop diversification or even expand their covered area to earn a higher income. The diversification levels can improve if farmers can increase the number of crops planted in their parcel or when the area becomes more evenly planted with various crops.

Meanwhile, resource endowments are important considerations in diversifying farms. Specifically, human and land resources emerged as significant factors affecting a farmer's choice of a production system. As generally risk-averse individuals, farmers may need to address constraints in these resources before adopting CD. Producing more than one crop at the same time is an intricate farming practice to pursue. It requires an understanding of the production process of each crop, the interaction between these crops, their impact on the ecosystem, as well as its proper postharvest handling. Farmers who are persistent and diligent learners are expected to easily shift from monocropping to CD.

The natural characteristics of land, such as soil type and topography, can also influence the cropping system choice of a farmer. Rice is a water-loving crop, thus, it is best grown in a continuously flooded area (IRRI n.d.) This field condition is easily achieved by farms with clayey soils, and by low-lying lands. Flooded areas, however, are unsuitable to a lot of high-value crops.

High capital requirement in producing high-value crops remains a challenge for CD farmers, and a constraint for monocroppers. Other farmers' concerns were on marketing and prices, and postharvest facilities. Farmers need to market their produce immediately because high-value crops (e.g., vegetables) are perishable. A sure market for these commodities is necessary. Moreover, a suitably located postharvest facility may help preserve the quality of their produce.

The implementation of the Masagana Rice Industry Development Program (MRIDP) of the Department of Agriculture will involve scaling up of rice technologies that are hoped to improve yields, reduce risks, and achieve farm resiliency. One of the technologies that will be rolled-out is the *Palayaman*, a rice-based production system developed by the Philippine Rice Research Institute (PhilRice), that embodies the concept of diversification, intensification, and integration of farming components (Corales et al. 2019). This study hopes that the recommendations discussed herein may be considered in its implementation.

Successful CD scaling-up efforts may have to involve an area suitability assessment that can aid in the selection and mapping of priority areas for CD; not all rice areas can be suitably grown with high-value crops. This is to initially invest the available limited government resources to the best candidate for CD, thus, greater impact. Identified possible rice farmer-adopters also need equipping in managing diversified farms, postharvest handling, and marketing. The best combination of crops to be planted with or after rice also needs to be carefully thought of, so as not to waste farmers' investment, identification of which has to be resource- and demand-driven. To efficiently accomplish these, active involvement of the Local Government Units (LGUs) is recommended as they are more familiar with their respective locality. Likewise, research institutions and the academe are also called to provide technical guidance on crop diversification to program implementers and farmers.

Farmer-group or cluster-managed marketing may be explored to help create volume and consequently leverage on better prices for the produce. Linking these farmers to a stable market (*e.g.*, institutional buyers) is another strategy to easily dispose of their commodities, hence, avoiding crop losses due to spoilage. Farm-to-market roads will also open an opportunity or motivation to diversify beyond subsistence farming.

Rice farmers' divestment from crop diversification was primarily due to its high capital requirement and low commodity prices. Government efforts, thus, should also aim at crafting ways to help reduce production costs or provide easy access to low-cost credit. Mechanizing farm work can save on labor costs. Pooling resources through clustering can also help create economies of scale for farm mechanization.

Information about CD, as reported by the farmer-respondents, were mainly sourced from co-farmers. An up-scaled awareness campaign and promotion is needed and must highlight CD's potential as a resiliency measure or an alternative choice for rice farmers vulnerable to climate change and other production challenges.

Crop diversification has been in existence for a long time, but was given minimal recognition on the ground. Scaling strategies should consider the evidence-based adoption barriers to successfully attain their objectives. This is then hoped to help create prosperous rice-based farming communities.

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