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Land Fragmentation Impact on Agricultural Mechanization for Rice Farmers in the Interior Municipalities in the 2nd District of Ilocos Sur

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Abstract

The study aimed to determine the socio-demographic profile of respondents, land fragmentation index, degree of utilization of farm machinery, comparative analysis on the cost of production of manually operated and man-machine operated rice farms, relationship of demographic profile and cost of production to the degree of utilization of farm machinery, and the econometric impact of land fragmentation.

The descriptive correlational research design was employed in this study. A survey questionnaire was used in gathering data. Frequency count, percentage, and means were employed for the demographic profile, and degree of utilization, respectively. Chi-square test, and Pearson correlation coefficient was used to determine the relationship of demographic profile, and cost of production to the degree of utilization, and also for the econometric impact of land fragmentation.

Majority of the farmer-respondents were IP members, male, in their mature working age, married, have 4-6 household members, finished high school, members of an association, had a farming income below poverty threshold level, had 1 farm parcel, had farms located within their barangay, had a subsistence farm area, had a rectangular shaped plots, had farm plots 0-4km away from their house, had a rainfed farm type, farmlands were man-machine operated, spent 7.01-9.0 hours working on-farm, and were farmer-lessees. The farmer-respondents within the study area tilled a number of small, disconnected planting plots for rice production which hampered the efficient utilization of farm machinery, and increased production cost. Most of the farm operations were done solely with the use of machinery operated by man. The comparative analysis using Analysis of Variance (ANOVA) was not employed in this study because there was only one farmer-respondent who utilized manual operation for his farm activities. The age, number of household members, sex, educational background, membership to association do not influence the degree of farm machinery use. There is a significant relationship between marital status and degree of utilization of farm machinery with respect to holding size. The degree of utilization of farm machinery does not affect the cost of production of rice. For the econometric impact, crop productivity and economic profitability of rice production was greatly affected by land fragmentation which also has a direct effect on the level of use of direct inputs, total production cost, and holding size. On the other hand, the number of household members do not affect crop productivity and farm profit. Hence, land fragmentation deters economic development.

It is strongly recommended to increase the holding size of rice farmers and reduce the magnitude of farm parcels. Land consolidation must be reinforced to lessen the cost of production, increase the efficiency of machinery use, increase rice production, and increase rice farming profit.

Keywords: Land Fragmentation Index, Degree of Utilization, Econometric Impact

1. Introduction

Background of the Study

Land fragmentation is an issue affecting agricultural development where agricultural lands are continually divided into increasingly smaller parcels, resulting in smaller operational landholdings that are often too small, limiting efficient production and hampering agricultural mechanization. The main cause of land fragmentation is population growth, which leads to more people sharing limited resources. Land fragmentation also increases production costs due to higher labor requirements and travel expenses to distant farm parcels.

Agricultural mechanization is a crucial element in the modern agricultural industry. It has enabled farmers to minimize tedious farm operations and reduce labor costs. By using mechanized tools and machines, farmers can save time and energy while ensuring that their crops are grown efficiently.

The Philippine government has been striving to develop and promote appropriate agricultural machinery and other mechanization technologies which would help address poverty, social equity, and food security, and enhance agricultural competitiveness and sustainable development leading to increased farmers' income (Bautista et al., 2017).

The introduction of agricultural mechanization raises the efficiency of farm operations and inputs and lowers production costs and postharvest losses (Bautista et al., 2017). Agricultural machinery may substitute for increasingly scarce labor (Lai et al., 2015). However, the Philippines is classified at a low-mechanization level due to the low buying power of farmers, the abundance of rural labor, very small landholdings per farmer, the high cost of machines, and government policies not favorable to mechanizing agriculture (Suministrado, 2013).

The national and local government have been distributing machinery, equipment, and facilities to farmers without assessing the status of their landholdings (plot size and fragmentation level) which often results in inappropriate, over-utilized, and under-utilized machinery. Due to the desire of farmers to avail themselves of every intervention given by the government, some of the programs implemented like subsidies given to farmers with smaller landholding sizes intensified the drastic division of farmlands. The inefficiency of the distributed interventions is inevitable due to the highly fragmented lands.

Farmers also do not make informed decisions when utilizing machinery to operate their farm regardless of the plot size, unrealizing the costs spent on fuel inputs and traveling expenses. Some rice farms are inaccessible especially in the upland because of their location and there is no farm-to-market road constructed going to the farmlands, so the farmers suffer a lack of manpower to work in their farms, to not waste their produce they just opt to work their rice farms on their own, manually. Land fragmentation unknowingly affects marginal farmers' productivity and financial aspects. The urge to mechanize agriculture is limited to highly fragmented lands and the efficiency of the machinery is not maximized due to small farm lots.

The lack of data on the inventory of farm machinery and the level of fragmentation leads to poor program implementation and policy interventions, and without a proper understanding of the factors of the cost of production as well as the application of appropriate machinery, farmers tend to have poor decision-making.

In 2002, Ilocos Region registered 276.8 thousand farms for agricultural use, covering 270.7 thousand hectares, or an average farm size of 0.98 hectare per farm. The region's total agricultural land area comprised 21.1 percent of the region's total land area. As the number of farms decreased by 11.2 percent from the 311.8 thousand farms reported in 1991, the average farm size likewise decreased by 0.06 hectare per farm. The region reported an average of 2.7 parcels per farm in 2002.

In 2002, Ilocos Sur registered 46.9 thousand farms for agricultural use, covering 36.1 thousand hectares, or an average farm size of 0.77 hectare per farm (NSO, 1991 Census of Agriculture and Fisheries and 2002 Census of Agriculture).

In 2012, Ilocos Sur registered 57 thousand farms for agricultural use, covering 34 thousand hectares, or an average farm size of 0.60 hectare per farm (PSA, Census of Agriculture and Fisheries 2012).

In terms of holding/farm size, 45 thousand holdings/farms reported in 2012 had sizes of less than 1.0 hectare. About 11 thousand farms were recorded with farm sizes between 1.0 hectare to 2.9 hectares. Another 1 thousand were registered to have farm sizes of 3.0 to 7.0 hectares. Less than 500 holdings/farms were recorded with a farm size of greater than 7.0 hectares.

In terms of the number of parcels, 23 thousand farms consisted of only one parcel. About 18 thousand farms comprised 2 parcels. Around 9 thousand farms consisted of 3 parcels. 7 thousand farms comprised of 4 or more parcels.

Regarding the legal status of holder/operator, 56 thousand farms were reported to be managed by individual proprietors and 1 thousand farms were operated by a partnership/corporation/cooperative.

Ilocos Sur reported 117 thousand farm parcels covering 34 thousand hectares. Each parcel in Ilocos Sur had an average area of 0.30 hectare. 46 thousand farm parcels were fully owned by the holders/farm operators, these fully-owned parcels covered 12 thousand hectares. Other holding/farm parcels were operated under owner-like possession with 14 thousand farm parcels covering 4 thousand hectares. 48 thousand farm parcels were tenanted covering 15 thousand hectares. 8 thousand farm parcels were leased/rented covering 2 thousand hectares. 2 thousand farm parcels were rented free or under CLT (Certificate of Land Transfer)/CLOA (Certificate of Land Ownership Award), CADT (Certificate of Ancestral Domain Title)/CALT (Certificate of Ancestral Land Title), CBFMA (Community Based Forest Management Agreement)/stewardship and other tenure status were reported covering less than 500 hectares.

93 thousand farm parcels covering 31 thousand hectares were utilized under temporary crops. In Ilocos Sur, Palay (Rice) was planted in 49 thousand farm parcels with an average size of 0.30 hectare per parcel (PSA, Census for Agriculture and Fisheries 2012).

As of March 14, 2023, there have been 59,165 RSBSA registered rice farmers in the 2nd district of Ilocos Sur as reflected in the statistics of the Department of Agriculture.

Promoting farm mechanization in the Philippines has been constrained by the small-sized, un-accessible rice fields, especially during the rainy season, and irregular, and nongeometric-shaped farm areas. Mechanizing these lands can be inefficient due to too much maneuvering in operations like land preparation and harvesting. The use of machinery and other large-scale agricultural practices is hampered (Bautista et. al, 2017).

In 2012, the estimated number of 4-wheel tractors in the Philippines was 9,306 units and 1,000,000 units of hand tractors (Suministrado, 2013).

According to Suministrado (2013), the level of mechanization of the following farm operations for rice crop are classified to wit: land preparation is intermediate to high, planting/transplanting is low, crop care cultivation is low, harvesting is low, threshing is intermediate to high, drying is low, and milling is high. In 2011, the recorded mechanization level of the Philippines was 2.31 hp/ha for rice (Agricultural Machinery Information Network).

Framework of the Study

Figure 1. Research Paradigm of the Study

INPUT		PROCESS		OUTPUT
➢ Socio-Demographic Profile ➢ Holding size ➢ Number of parcels belonging to the holding ➢ Size of each parcel ➢ Shape of each parcel ➢ Spatial distribution of parcels ➢ Size distribution of parcels ➢ Total no. of RSBSA registered rice farmers ➢ Total area planted with rice ➢ Total no. of parcels ➢ Average landholdings of farmers ➢ No. of rice farmers with machinery ➢ Type of machinery used in rice production and post-harvest operations ➢ Cost of production for 1-ha rice farm	⇨	➢ Coordination and briefing with the LGUs ➢ Reproduction of Survey Questionnaire ➢ Collection of data from DA RFO I ➢ Conduct of survey ➢ Consolidation of data ➢ Analysis of Data	⇨	➢ Data on the degree of utilization of agricultural machinery ➢ Financial analysis of manually and man-machine operated rice farms ➢ Land fragmentation index ➢ Econometric impact of land fragmentation

Figure 1 presents the research paradigm of the study which includes the Input-Process-Output Model. The input phase includes the socio-demographic profile, the six parameters associated with land fragmentation which are holding size, number of parcels belonging to the holding, size of each parcel, shape of each parcel, spatial distribution of parcels, and size distribution of parcels, and it also includes the total number of RSBSA registered rice farmers, the total area planted with rice, the total number of parcels, the average landholdings of farmers, the number of rice farmers with machinery, the type of machinery used in rice production and postharvest operations, and the cost of production for 1-ha rice farm. The process phase includes coordination and briefing with the LGUs, reproduction of survey questionnaire, collection of data from DA RFO I, conduct of survey, consolidation of data, and analysis of data. Lastly, for the output phase, the researcher will present the data on the degree of utilization of agricultural machinery, the financial analysis of manually and man-machine operated rice farms, the land fragmentation index, and the econometric impact of land fragmentation.

Statement of the Problem

The study aimed to determine the impact of land fragmentation on agricultural mechanization for rice farmers in the interior municipalities in the 2nd district of Ilocos Sur.

Specifically, it sought to:

1. Determine the socio-demographic profile of respondents in terms of:
   a. Geographic identification (region, province, and municipality)
   b. General information (IP member, sex, age, marital status, number of household members, educational background, and membership to association/organization)
   c. Rice farm profile (gross annual income, and number of farm parcels planted with rice)
   d. Farmland description (farm location, farm area, plot shape, distance from house to plot, farm type, classification of operation, on-farm working hours, and tenurial status)
2. Determine the land fragmentation index
3. Determine the degree of utilization of farm machinery/equipment/facility
4. Comparative analysis on the cost of production of manually operated vs man-machine operated rice farms based on the last cropping season along with the price of inputs
5. Determine the relationship of the demographic profile to the degree of utilization of farm machinery
6. Determine the relationship of the degree of utilization of the farm machinery to the cost of production
7. Determine the econometric impact of land fragmentation

Hypotheses

Ha : No significant relationship between the demographic profile and degree of utilization of farm machinery

Ha : No significant relationship between the degree of utilization of farm machinery and cost of production

Scope and Limitations of the Study

The study focused on the impact of land fragmentation on agricultural mechanization that covered only the interior municipalities in the 2nd district of Ilocos Sur, namely: Alilem, Banayoyo, Burgos, Cervantes, Galimuyod, Gregorio del Pilar, Lidlidda, Nagbukel, Quirino, Salcedo, San Emilio, Sigay, Sugpon, and Suyo. Data were collected from the Department of Agriculture RFO – I, Local Government Units, and Rice Farmers enrolled in the RSBSA per municipality with survey questionnaire as instrument to facilitate data collection and as reference. Farmers not enrolled in the RSBSA are not within the scope of this research. The study was conducted from March 2023 to April 2024. The results of the study will apply only to the above-mentioned municipalities and barangays located therein.

Importance of the Study

This study serves as a guide to development planners or policymakers of agricultural agencies to formulate appropriate agricultural policies, to properly allocate funds/resources for the provision of appropriate agricultural machinery for rice farmers, and to formulate strategies for enhancing farm mechanization in small-farm size production systems uplifting farmers farming practices and income.

Research institutes may use this study as a basis for research innovation of portable or village-type machi-

nery designed for fragmented lands.
This will be useful as a reference for the decision-making of rice farmers for the appropriate application of machinery.

Review of Literature

As cited by Lai et al. (2015) in their study, there have been few studies that directly investigated the relationship between land fragmentation and investment in farm machinery which found that farmers with more land will invest more in machinery to exploit economies of scale and that larger plots are associated with higher profits per acre. On the other hand, mechanization on the smallest farms requires costly investment in specialized machines that small farmers may be loath to make. Following this logic, full efficiencies of mechanization are not available in such a fragmented agricultural landscape. Furthermore, they also stated that extant research confirms that land fragmentation leads to lower productivity and higher cost. (Lai et al., 2015).

According to the study of Huo et al. (2022), farmers in different regions have varying barriers in machinery use. They cited that most farmers consider land fragmentation and lack of machinery training an important barrier to using machinery. Whereas cooperative directors cited land fragmentation as the greatest barrier to machinery use.

Liu et al. (2013) and Jetté-Nantel, Hu, and Liu (2014) found that an increased labor price increases farmers' adoption of large machinery, and large machinery is associated with higher productivity on larger plots, which may indirectly suggest that land fragmentation may hamper the diffusion of larger machinery. Lai et al. (2015) found that consolidating an average farm of 0.31 hectares from 2.28 plots to one plot increases machinery use by about 10% and that a 10% increase in machinery use increases crop production between 0.5% and 1%.

Land fragmentation has significant negative effects on machinery use. A one-unit increase in land fragmentation reduces machinery use by 23.2% and 30% for wheat and corn, respectively. This is consistent with the rationale that land fragmentation causes extra labor and fuel inputs, the time wasted traveling from plot to plot, or the difficulty of accommodating machinery to small, irregularly shaped fields (Lai et al., 2015). The impact of land fragmentation on crop production now becomes significant because insufficient surplus labor can compensate for the loss from less efficient usage of machinery due to scattered land management. This suggests that large machinery tends to be a complement to larger plots. According to Tan et al., reducing the average distance to plots and increasing farm size decreased the total production costs per ton. Farmers with smaller plots tend to use fewer modern technologies.

The plentiful supply of farm labor is now more limited (Lai et al., 2015), and the level of mechanization in the Philippines is low (Suministrado, 2013). Small and scattered plots hamper the use of machinery and other large-scale agricultural practices. Land fragmentation causes inefficiency in the allocation of government funds/resources for example machinery interventions are sometimes inappropriate, under-utilized, and over-utilized. Fragmented lands are associated with more labor devoted to farming and it is still believed to hinder the use of both machinery sources because fragmented lands require extra labor and fuel inputs, extra time traveling from one plot to another, and heightened skill to accommodate machinery to small, irregularly shaped fields (Bentley 1987) and the inability to use certain types of machinery.

He (2014) stated that land fragmentation is an obstacle to the optimization of land use efficiency. This is because farm characteristic variables directly impact production efficiency and therefore affect production costs. The plot size and the number of plots are commonly considered to increase the costs because the spatially separated plots hinder the use of modern agricultural mechanization. The result of his study confirms the negative influence of farm size on the total production cost. He stated that we can expect a lower total production cost per unit output from the larger farm size. In detail, a 1% increase in farm size leads to a 0.11% reduction in total wheat production cost. The farm size shows a significant negative influence on labor, irrigation water, and seed costs. It is noted that with a 1% increase in the farm size, the labor cost per unit output decreases by 0.17%. The irrigation water and seed cost are expected to decline by 0.25% and 0.13%, respectively, when farm size increases by 1% size. The findings indicate that the larger farm size reinforces the economies of scale, by which the household can improve the production efficiency of labor, irrigation, and seed and therefore, causing lower costs per unit output.

In terms of farm landholding, Bautista et al. (2017) found that improving the plot size will improve the efficiency of machinery utilization due to less unproductive time during turnings. Their study had shown that the relationship between total farm area owned, and machine ownership of the farmer-respondents have a positive but weak correlation which indicated that as farm landholding increases, machine ownership also increases.

In relation to farm machine utilization per operation, the survey of Bautista et al. (2017) had shown that land preparation was 100% mechanized using hand and four-wheel tractors for plowing and harrowing. Seedling preparation and pulling seem to be manually done; 18% used machines for hauling seedlings from the seedbed to the production area. Transplanting was done manually but five farmer-respondents (0.8%) used the drum seeder in direct seeding. Only 14% of the farmers used water pumps for irrigation. About 50% used hand tractors in hauling farm inputs and 50% used man-animal. 15% used the reaper or combine harvester for harvesting. Most farmers (85%) used the axial-flow thresher.

Latruffe et al. (2014) investigated the impact of land fragmentation on farm performance in terms of production costs, yields, revenue, profitability, technical, and scale efficiency and found that land fragmentation increases production costs and decreases yields, revenue, profitability, and efficiency. Furthermore, stated that it is relevant to consider the various dimensions of land fragmentation, particularly the shape and distance considerations when studying its impact on farm performance.

According to Wang et al. (2020), when fragmentation becomes severe, mechanizing agriculture will be difficult, and farmers will instead choose to increase labor input, which increases the overall production costs. They found that farm scale and production cost have an inverted U-shaped relationship that is when the farm scale exceeds 47 mu or 3.13 ha the cost decreases. However, the average farm scale under the study area is currently 6.06 mu or 0.40 ha.

2. Methodology

Research Design

The descriptive correlational research design was used in this study wherein data such as geographic identification, general information, farm profile, farmland description, machinery/equipment/facility profile, degree of utilization of farm machinery, and cost and return analysis of rice production were gathered and collated.

Population and Locale of the Study

The study area is in the interior municipalities in the 2nd District of Ilocos Sur and consists of the municipalities of Alilem, Banayoyo, Burgos, Cervantes, Galimuyod, Gregorio del Pilar, Lidlidda,

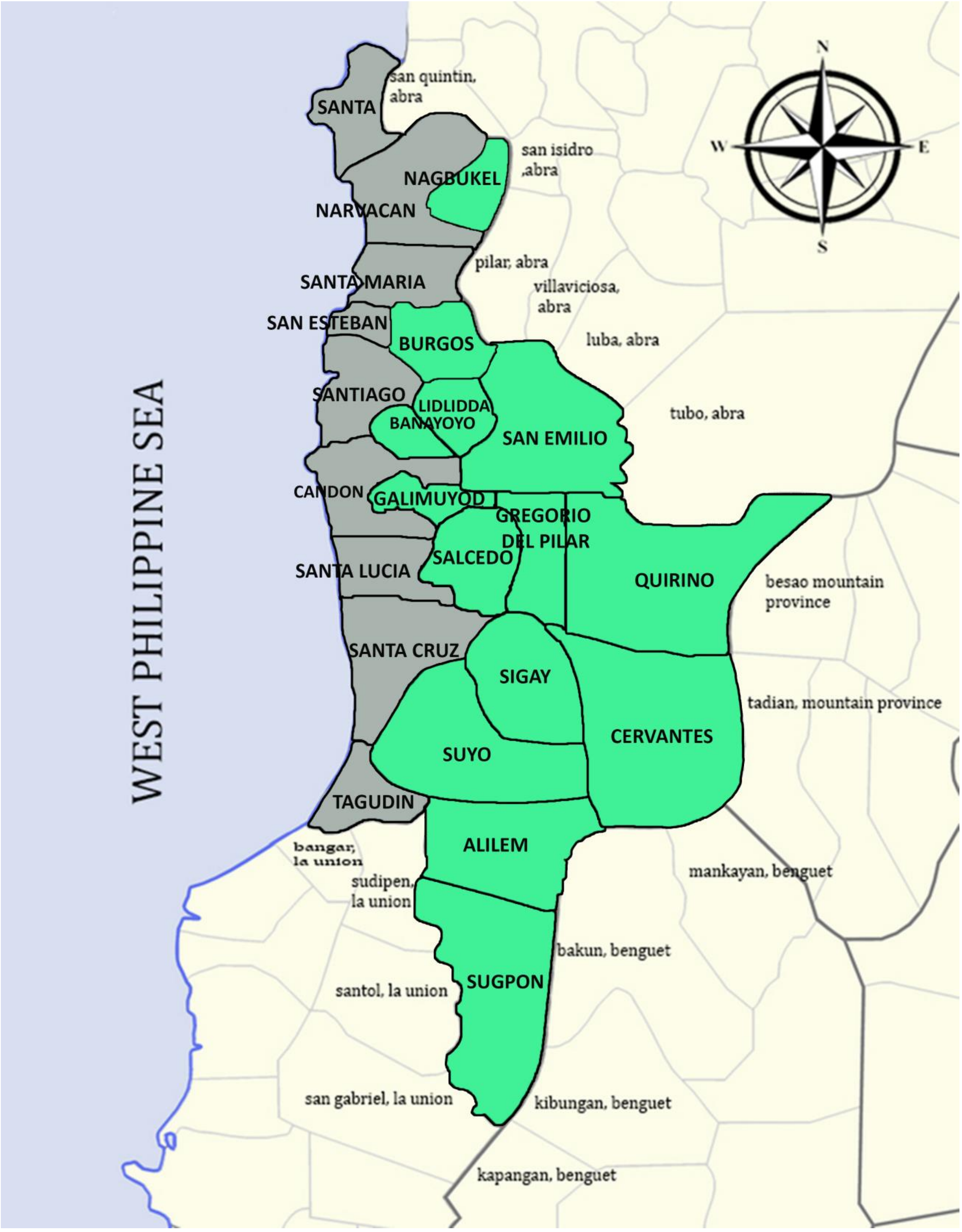
Nagbukel, Quirino, Salcedo, San Emilio, Sigay, Sugpon, and Suyo. RSBSA-enrolled rice farmers of the said municipalities were considered as subjects in this study.
G*Power was used to determine the sample size. The sampling frame came from the Registry System for Basic Sectors in Agriculture which was obtained from the Department of Agriculture.

Table 1. Number of RSBSA Registered Rice Farmers in the Interior Municipalities in the 2nd District of Ilocos Sur

Municipality	Population	Sample
Alilem	2,655	40
Banayoyo	945	25
Burgos	2,239	37
Cervantes	3,121	43
Galimuyod	2,273	39
Gregorio del Pilar	1,155	34
Lidlidda	1,281	36
Nagbukel	1,129	34
Quirino	2,237	39
Salcedo	1,635	37
San Emilio	1,922	38
Sigay	786	25
Sugpon	1,118	34
Suyo	2,129	39
Grandtotal	**24,625**	**500**

Data as of March 14, 2023
Source of data: Department of Agriculture RFO 1

Figure 2. Map of the Study Area



Land Fragmentation Index

Simpson index was used to determine the land fragmentation index which took into account the number of parcels in a holding and the relative size of each parcel. With the formula:

$$FI = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \qquad (1)$$

where:

FI = fragmentation index
n = number of parcels belonging to a holding
A = total holding size
a = size of a parcel

An FI value of 1 means that a holding consists of only one parcel and values closer to zero mean higher fragmentation.

Econometric Impact Model

In order to measure the impact of land fragmentation on crop productivity an econometric model was used, expressed using the following equation:

$$Y=-0.37F+0.59X_1+0.74X_2+0.82X_3+0.81X_4+0.81X_5+0.07X_6 \quad (2)$$

where:

Y	=	crop productivity
F	=	level of fragmentation
X_1, X_2, X_3	=	direct inputs: seeds (kg), fertilizers (kg), and machine-use (Php)
X_4	=	Total cost of production (Php)
X_5	=	Holding size (ha)
X_6	=	Number of household members

The dependent variable is the crop productivity (Y) which is defined as the value of harvested crops per planting area.

The equation determines the correlation of the level of fragmentation with respect to plot size, and number of farm parcels; direct inputs; total cost of production; holding size; and number of household members to crop productivity.

As a measure of fragmentation, the Simpson's index was used.

Research Instrument

Survey questionnaire was used in gathering data. It consists of four parts wherein Part I gathers the socio-demographic profile of the farmer-respondents which was based on the RSBSA enrolment form of the Department of Agriculture in terms of geographic identification, general information, rice farm profile, and farmland description. Part II gathers the degree of utilization of the farm machinery/equipment/facility using the 5-point Likert scale with the following descriptive rating: always utilized, often utilized, moderately utilized, seldom utilized, and not at all utilized. Part III gathers the cost and return analysis of rice production which was based on the PhilRice monitoring form and PCIC crop insurance form, particularly on the cost of production inputs. A face-to-face interview was conducted with the rice farmers in the field survey. An informal type of interview was also conducted with a farmer-representative per municipality as part of the impact analysis.

Data Processing/Data Analysis

Data collected from the survey were processed, arranged, and presented in tables and pie charts. For the demographic profile, frequency count and percentage were employed. For the degree of utilization, means was used. For the relationship of the demographic profile to the degree of utilization, and the degree of utilization to the cost of production, Chi-Square test and Pearson Correlation Coefficient were used. The impact of land fragmentation to crop productivity (total value of harvested crop/total area) was statistically analyzed using Pearson Correlation Coefficient.

Data Categorization

A five-point Likert scale was used in determining the degree of utilization of agricultural machinery/equipment/facility

Scale points for rating	Statistical Limit	Descriptive Equivalent	Rating
5	4.21 – 5.00	Always utilized	AU
4	3.41 – 4.20	Often utilized	OU
3	2.61 – 3.40	Moderately utilized	MU
2	1.81 – 2.60	Seldom utilized	SU
1	1.00 – 1.80	Not at all utilized	NU

The following were the descriptions that was used as basis for the ratings:

Always utilized :	100% usage. The operation was done solely with the use of the machinery operated by man.
Often utilized :	75% usage. The machinery was more frequently used than usual but manual operation was an alternative when the machinery was not available.
Moderately utilized :	50% usage. The machinery was used more than once. The operation was done with the use of machinery operated by man in combination with the use of a manual operation.
Seldom utilized :	25% usage. The machinery was used once in a while. Manual operation was much more used than machinery.
Not at all utilized :	0% usage. The machinery was never utilized.

3. Findings

Socio-demographic Profile of Respondents

Geographic Identification. Contains the data on the region, province, and municipality of the rice farmer-respondents.

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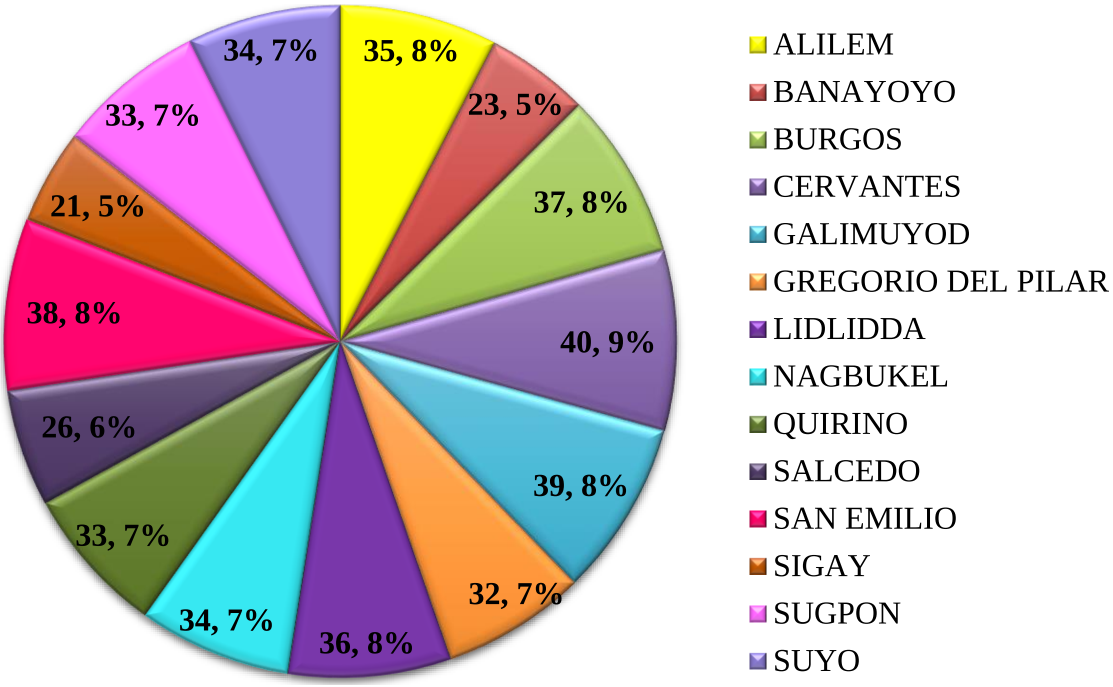
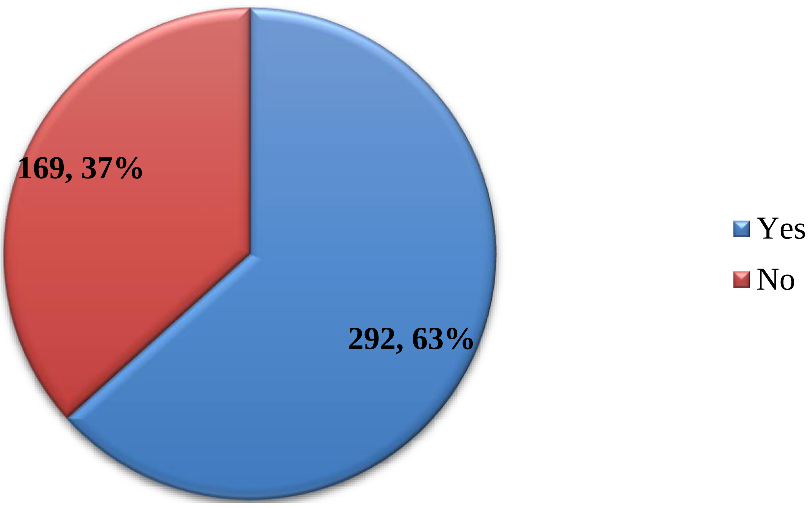
Figure 3. Distribution of Sample



The 500 RSBSA registered rice farmer-respondents were from the interior municipalities in the 2nd district of the Province of Ilocos Sur, Region 1. The number of sample sizes per municipality was determined using G*Power. However, 461 RSBSA registered rice farmer-respondents with machinery were considered subjects in this study as reflected in Figure 3.

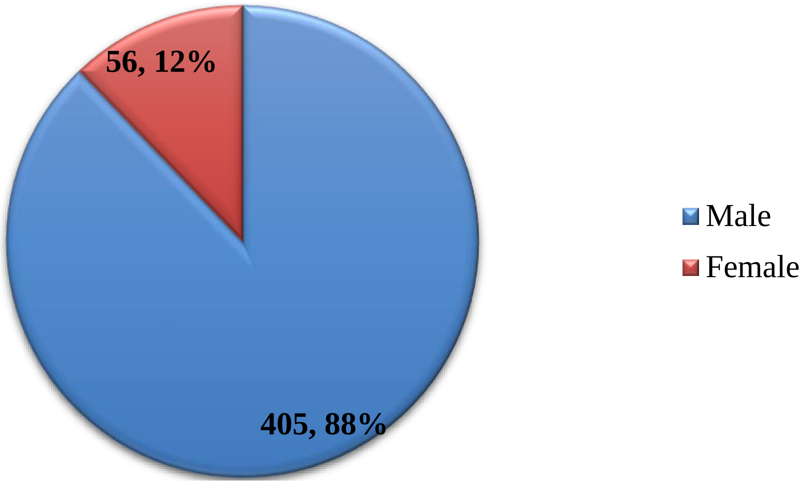
General Information. Includes the data on the farmer-respondents' indigenous people membership, sex, age, marital status, number of household members, educational background, and membership to association/organization.

Figure 4. Indigenous People Member



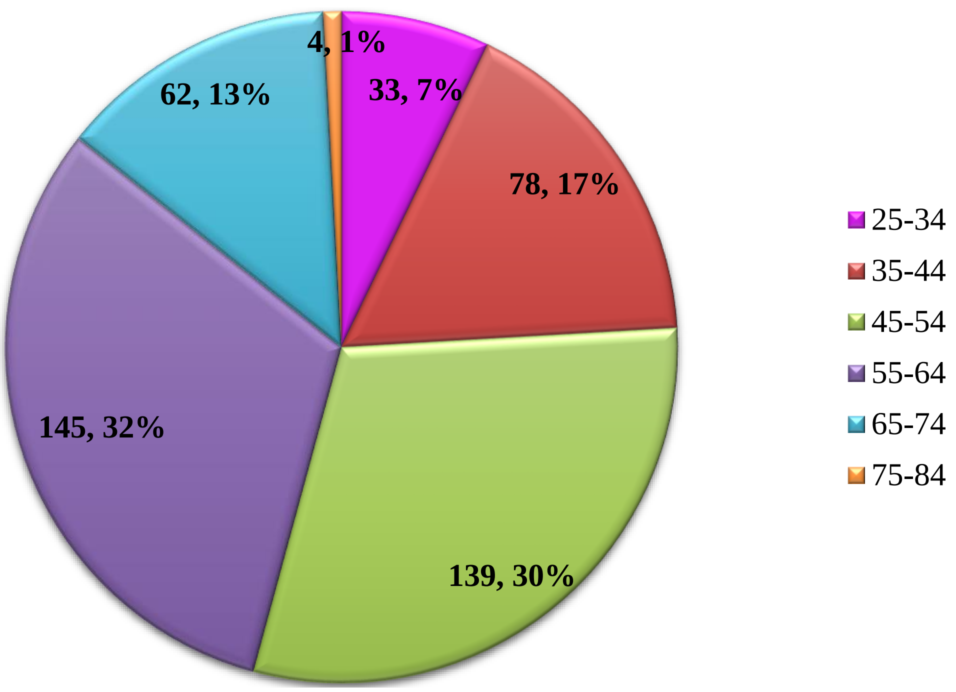
Indigenous People Member. In Figure 4, out of the 461 RSBSA registered rice farmer-respondents, 292 (63%) were members of indigenous people's groups, namely: Kankanaey, Tinguians, Bago, Applai, and Igorot, while 169 (37%) of the rice farmer-respondents were full-blooded Iloco.

Figure 5. Sex



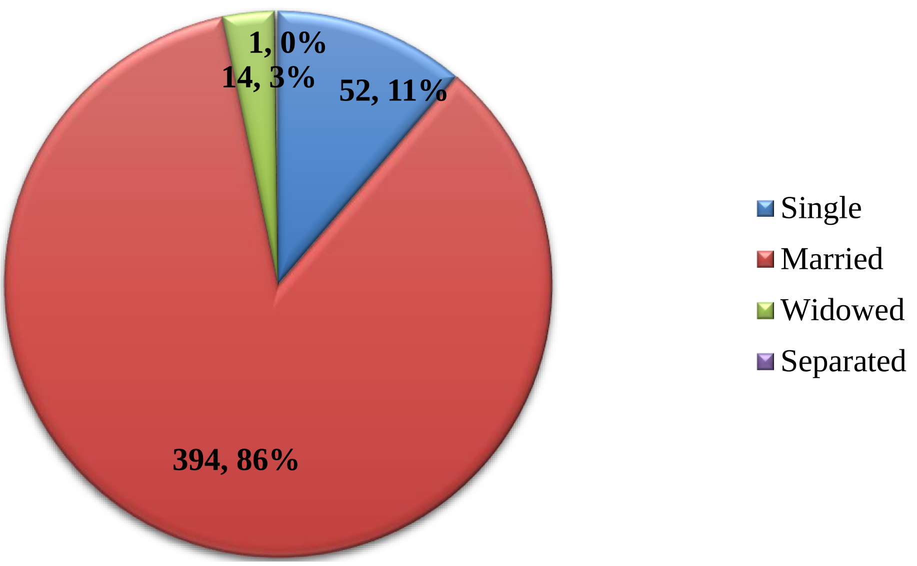
Sex. Figure 5 presents that majority of the rice farmer-respondents in the study area were male (405, 88%), and only 56 (12%) rice farmer-respondents were female. It was found that the agricultural workforce was dominated by men because they do most of the farm activities as compared to women who mostly do managerial work and light-duty. This corroborates with the study of Dalman et al. (2023) that males do most of the farm operations like land preparation, seedbed preparation, and irrigation canal maintenance, while women in agricultural workforce are essential in planting, transplanting, manual weeding, and manual harvesting. In connection with machinery adoption Masset et al. (2023) found that mechanical technology is more likely to be adopted by farms managed by men and the households' use of tractors and/or combine-harvesters lead to reduced engagements of women in the agricultural sector (Takeshima et al., 2021).

Figure 6. Age of RSBSA-Registered Rice Farmer-Respondents



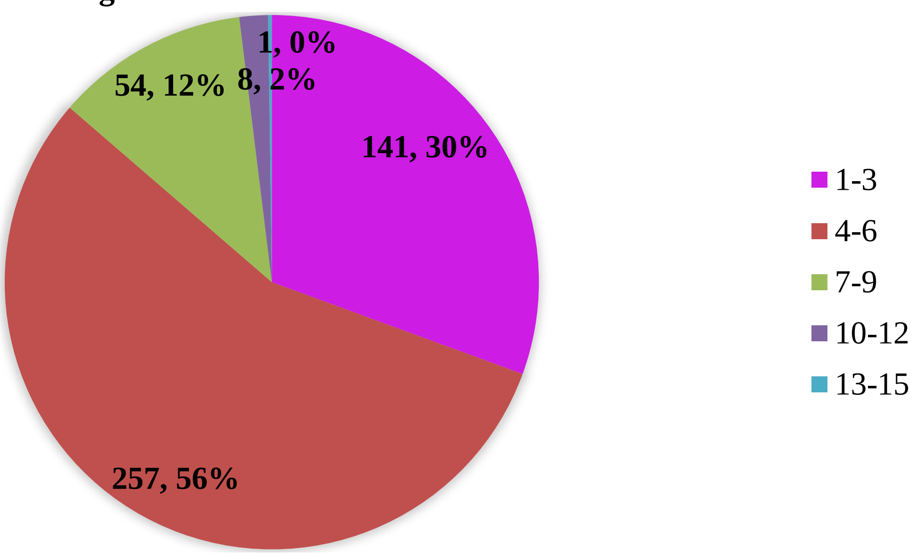
Age. Data shows in Figure 6 that the age of rice farmer-respondents ranged from 25-84 years old. Most of the farmer-respondents were at their mature working age (55-64 years old). Few were old dependents (65 years and over). According to Suswadi et al. (2023), farmers at the age of 18-65 still can improve skills in farming by absorbing and adopting new technology/modern machinery in farming to increase their income and productivity.

Figure 7. Marital Status



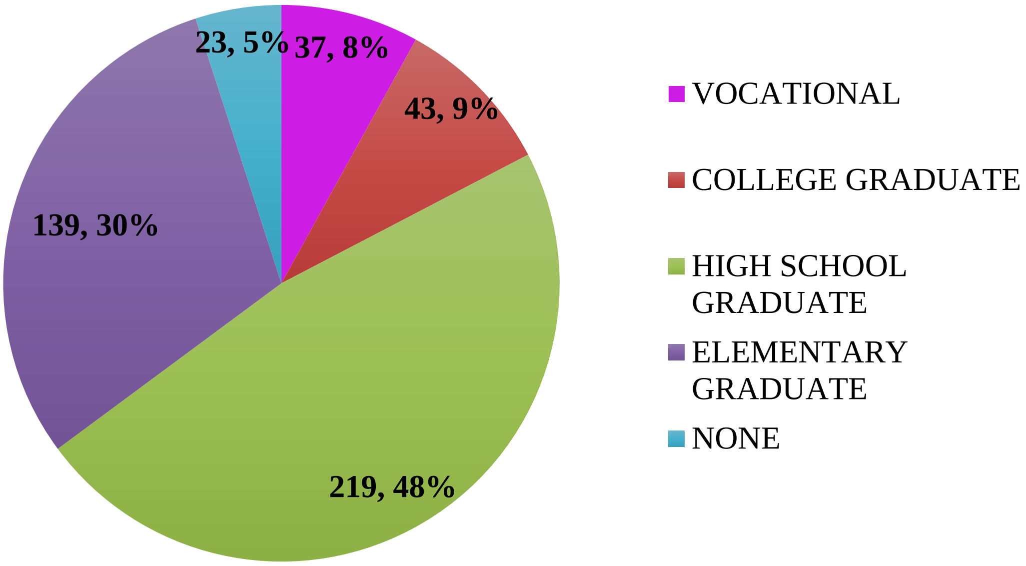
Marital Status. Figure 7 shows that majority of the farmer-respondents were married (394), and only 1 farmer-respondent was separated. This implies that the married ones are most likely to participate in agricultural activities than unmarried ones due to the fact that the married ones have more family responsibilities to meet their family's socio-economic needs (Kimaro et al., 2015). In terms of machinery use, Onomu and Aliber (2021) found that tractor use appears to have a relationship with marital status, with almost all tractor users in their study area were married.

Figure 8. Number of Household Members



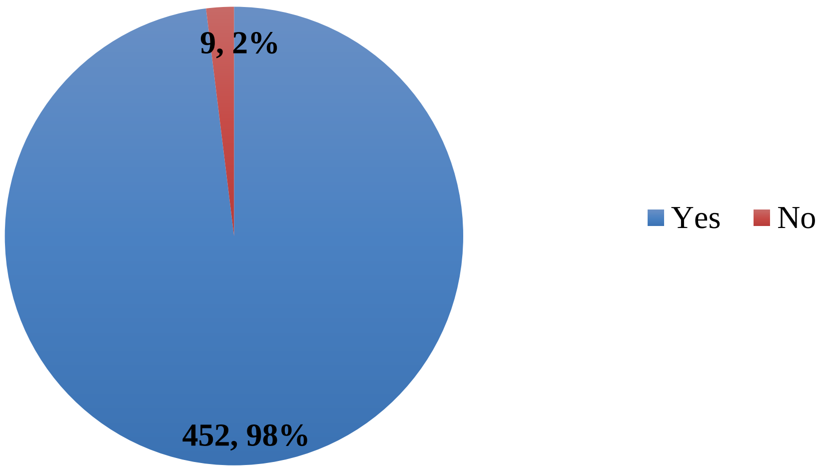
Number of Household Members. Most of the farmer-respondents were composed of 4-6 household members (Figure 8). And only 1 farmer-respondent have 13-15 household members. The PSA posted that there were 4.1 persons, on average, per household in 2020. The study of Ma et al. (2018) and Apiors et al. (2016) revealed that household size has a negative and statistically significant impact on machinery use wherein larger households potentially have a greater supply of family farm labor, which leads to less need for labor-saving technologies such as machinery, and rice farmer with smaller household size were more likely to intensify the use of mechanization.

Figure 9. Educational Background



Educational Background. Figure 9 shows that most of the rice farmer-respondents were high school graduates (219, 48%). There were only 23 (5%) farmer-respondents who were not able to avail education. It implies that most of the respondents who engaged in farming were those who did not attain a degree. The study of Dalman et al. (2023), Onomu and Aliber (2021), and Corner-Thomas et al. (2015) found that higher levels of education positively correlate with increased productivity and machinery use. Apiors et al. (2016) also found that the number of years of education negatively influences inefficiency of mechanization in rice farms which could be attributed to the fact that as farmers spend more years on formal education, they turn to adopt technologies that in turn reduce inefficiency.

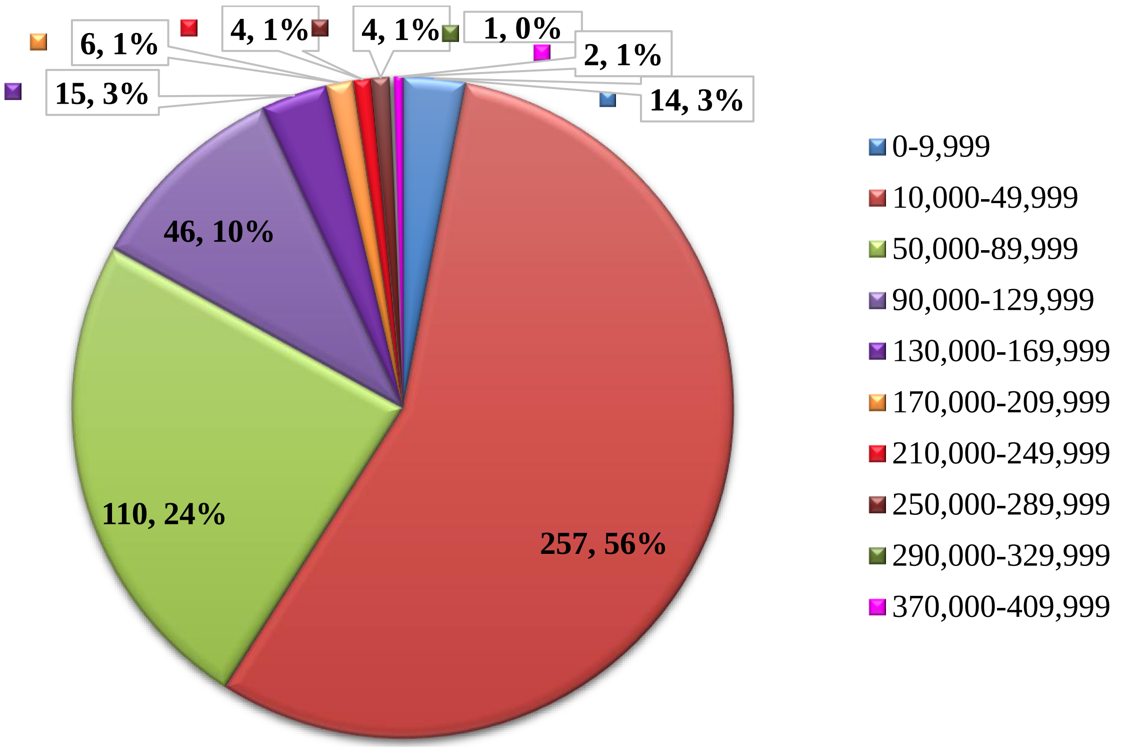
Figure 10. Member of Association/Organization



Membership to Association/Organization. Figure 10 shows that majority of the rice farmer-respondents were members of farmers' associations/organizations (452, 98%), and only 9 (2%) farmer-respondents were not affiliated to any farmers' associations/organizations. It was revealed that most of the respondents chose to be a part of an association because of the privileges offered to its members such as the benefit of using the machinery-properties with lesser rental fee, free farm inputs, market linkage, etc. Zhang et al. (2020) stated that cooperative membership has a positive effect on the technology adoption, significantly in terms of the number of postharvest technologies adopted. Verhofstadt and Maertens (2013) found that cooperative membership led to adoption of modern inputs, increased intensification, increased commercialization of farm produce, and higher revenue and farm income.

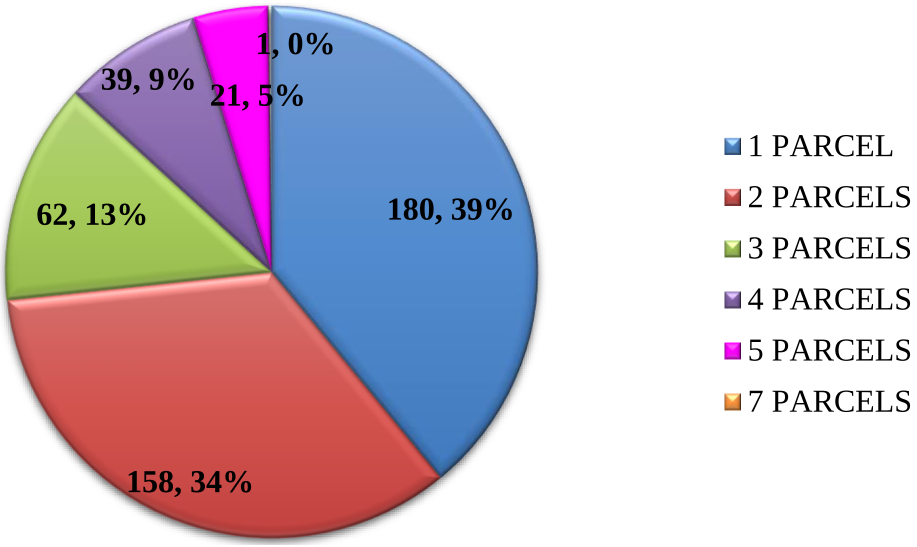
Rice Farm Profile. Includes the data on the gross annual income of the farmer-respondents, and the number of farm parcels planted with rice.

Figure 11. Gross Annual Income



Gross Annual Income. Figure 11 shows that most of the farmer-respondents had a gross annual income of Php 10,000.00 to Php 49,999.00, and only 1 farmer-respondent had a gross annual income of Php 290,000.00 to Php 329, 999.00. This is because most of the respondents have small holding size resulting to small rice production which generates small farming income. This revealed that the gross annual income of the farmer-respondents on their rice production was below the poverty threshold level specified by the Philippine Statistics Authority (2023). Ibendhal (2015) stated that the most profitable farms (farmlands worked intensively) have the highest machinery investment per acre and the highest total crop expenses as well as the highest depreciation costs.

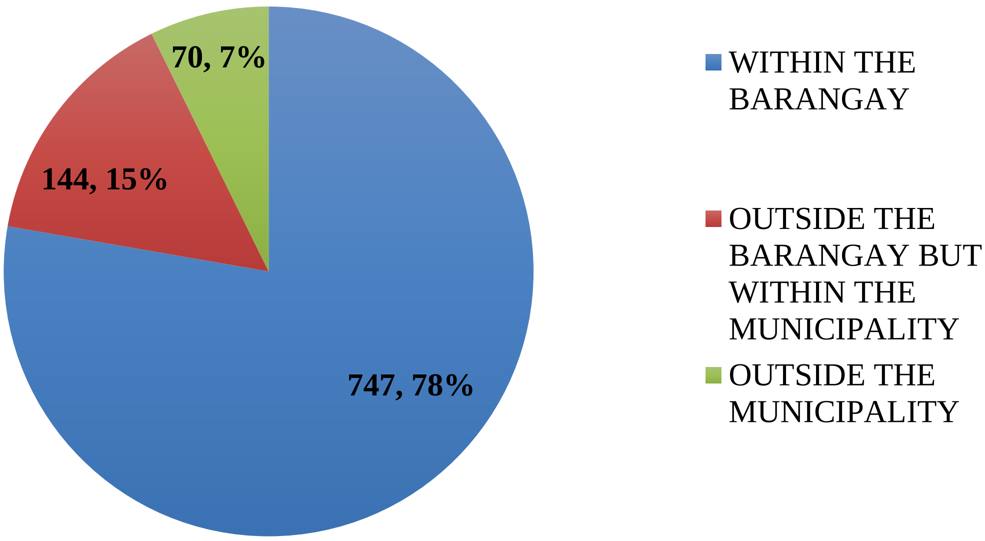
Figure 12. Number of Farm Parcels Planted with Rice



Number of Farm Parcels Planted with Rice. Figure 12 shows that the total number of farm parcels of the 461 farmer-respondents were 950. Most of the farmer-respondents (180, 39%) have 1 farm parcel, and only 1 farmer-respondent had 7 farm parcels intended for rice production. The study of Dhakal and Khanal (2018) stated that the number of parcels increase over time but the farm size decreases thereby increasing the per hectare use of inputs (fuel of machinery used) for households having large number of parcels since the distance to travel is comparatively higher. According to the study of Lai et al. (2015) and Wang et al. (2020), land fragmentation decreases machinery use but consolidating an average farm of 0.31 hectares from 2.28 plots to one plot increases machinery use by about 10%.

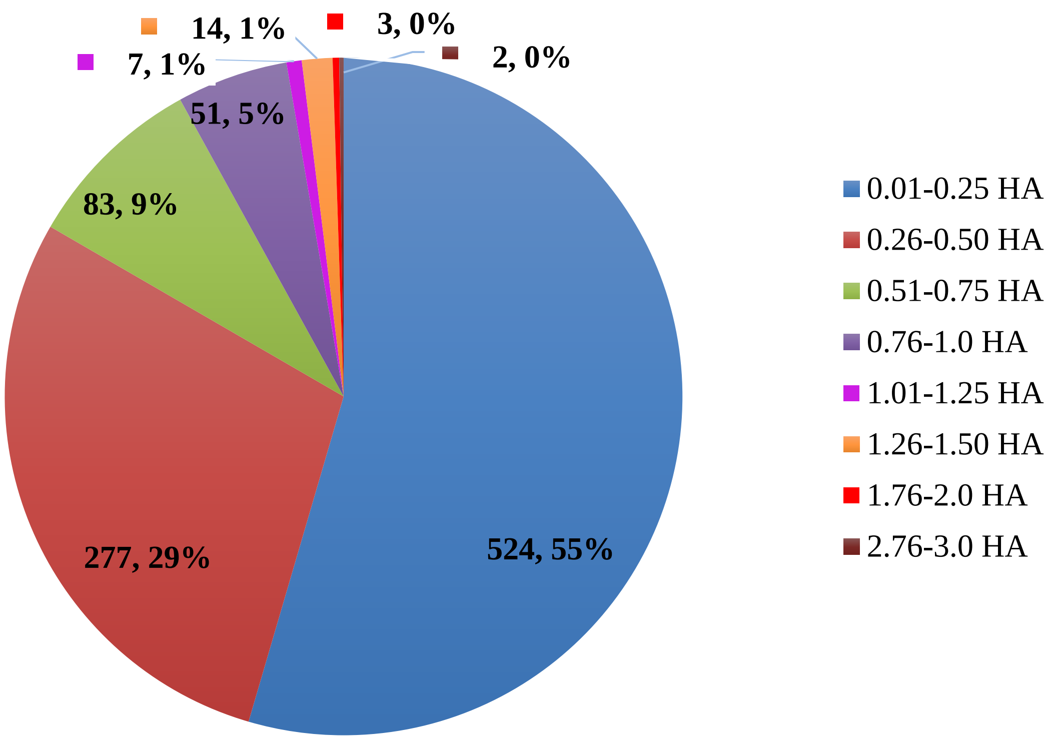
Farmland Description. Presents the data on the farm location, farm area, plot shape, distance from house to plot, farm type, classification of operation, on-farm working hours, and tenurial status of the rice farmer-respondents.

Figure 13. Farm Location



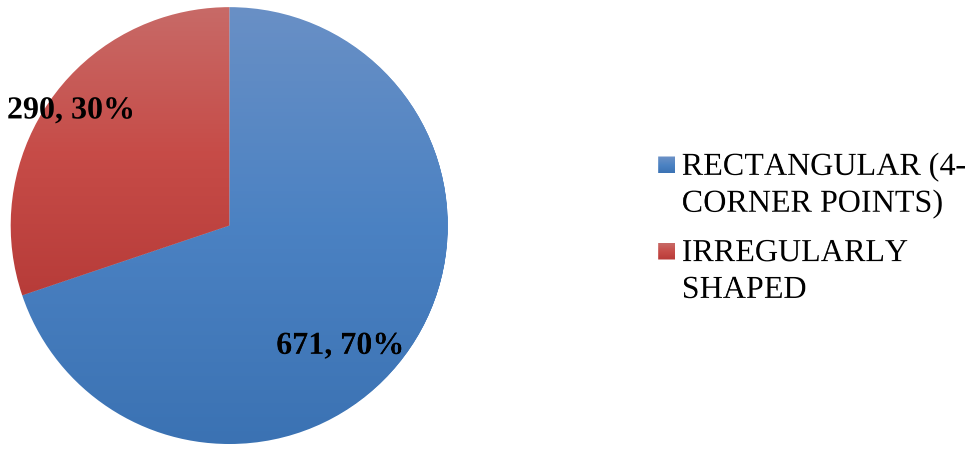
Farm Location. Figure 13 shows that most of the farm parcels (747, 78%) tilled by the farmer-respondents were located within their barangay, and only few farm parcels (70, 7%) were situated outside the municipality of the farmer-respondents. It was found that the farm location of the farmer-tenants and lessees depended on the availability of the farm parcels to be tilled. For the land owners, whose farmlands were located outside the municipality, they still opted to till their farmlands because they do not want to waste their resources.

Figure 14. Farm Area



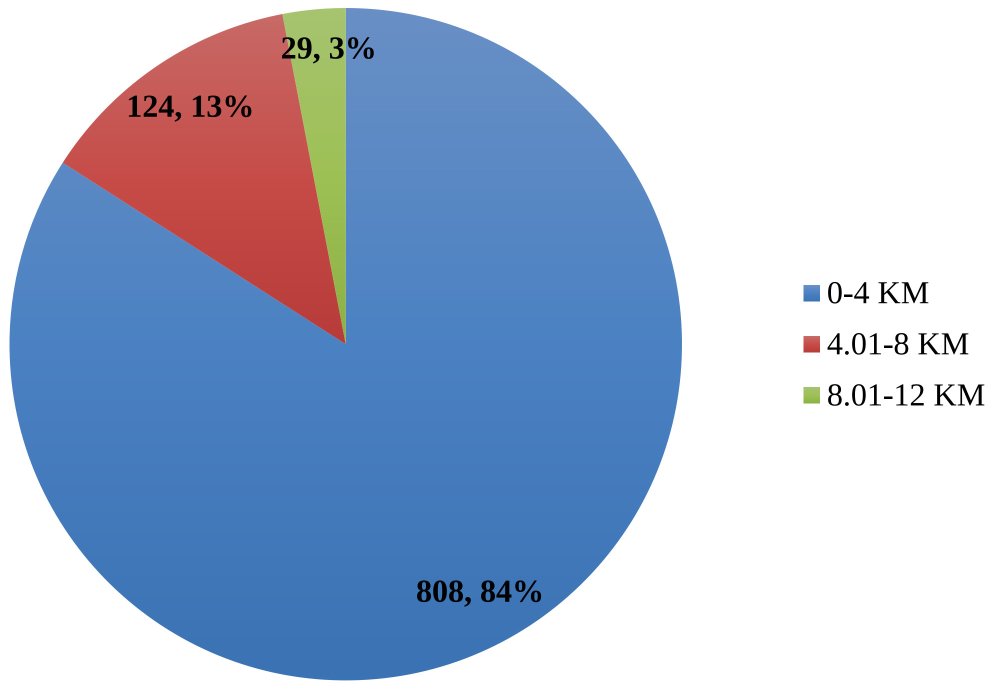
Farm Area. Figure 14 shows that the farm area of the farmer-respondents ranged from 0.01 hectare to 3 hectares only. Most of the recorded farm parcels (524) had sizes 0.01 hectare to 0.25 hectare, and only 2 farm parcels had sizes 2.76 hectares to 3.0 hectares. This indicates that most of the farm parcels were smaller than the recorded average size of a small-scale family farm in the Philippines that is 1.29 hectares (SEARCA, 2018) thereby reducing the efficient utilization of farm machinery due to unproductive time maneuvering, and generating small rice production. This implies that most of the farmer-respondents were engaged in subsistence farming wherein they consume most of their produce leaving little or nothing to be marketed, which is not ideal for the utilization of larger farm machinery. This agrees with the study of Dhakal and Khanal (2018) which indicated that large number of people depends on small size of land for their subsistence and land patches are increasing. The study of Ma et al. (2018), and Onomu and Aliber (2021) showed that the higher the area cultivated, the greater the likelihood of the farmer to use farm machines. This is also consistent with the study of Bautista et al. (2017) that improving plot size will improve the efficiency of machinery utilization due to less unproductive time during turnings, and an increased landholding results to increased machine ownership. Moreover, the result contradicts the findings of Kalita (2018) which showed that the use of machinery in agriculture fields was irrespective to the size of farm wherein there is no indication of larger farmers tending to use machines. However, the larger farmers emerge as the market leader.

Figure 15. Plot Shape



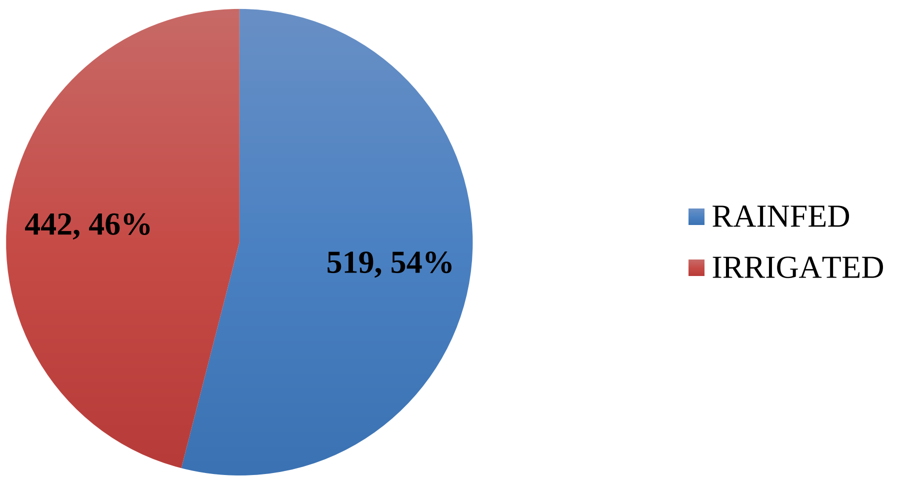
Plot Shape. Figure 15 shows that most of the farm parcels (671, 70%) tilled by the farmer-respondents have a rectangular shape, while 290 (30%) farm parcels have an irregular shape. This indicates that most of the farmer-respondents have a rectangular plot shape ideal for efficient machinery operation due to lesser time spent in complicated turns. This validates the study of Borbar et.al (2018) that plot size and shape affect operational capacity wherein effective and operational capacities are higher in longer plots, lengthwise, while maneuvering times are also shorter. Whereas, shorter plots result in efficiency losses. This also supports the findings of Griffel et al. (2020) that the larger the area, the more time is spent in parallel passes compared to turns.

Figure 16. Distance from House to Plot



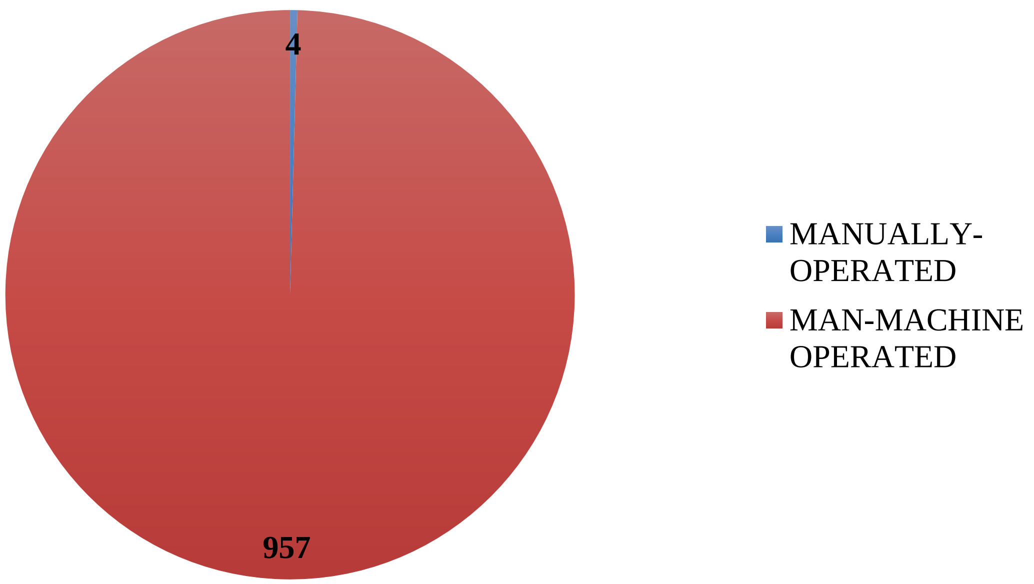
Distance from House to Plot. Figure 16 shows that majority of the farm parcels of the farmer-respondents were 0-4km away from their house (808, 84%), and only 29 (3%) farm parcels were 8.01-12km away from the farmer-respondents' house. This indicates that most of the planting plots of the respondents were located near their house which saves extra time and fuel inputs for traveling thereby reducing their total production cost. This supports the study of Dhakal and Khanal (2018) that as the distance from house to plot increases, there is an increase in the expenses on the fuel cost on machinery use for its transportation.

Figure 17. Farm Type



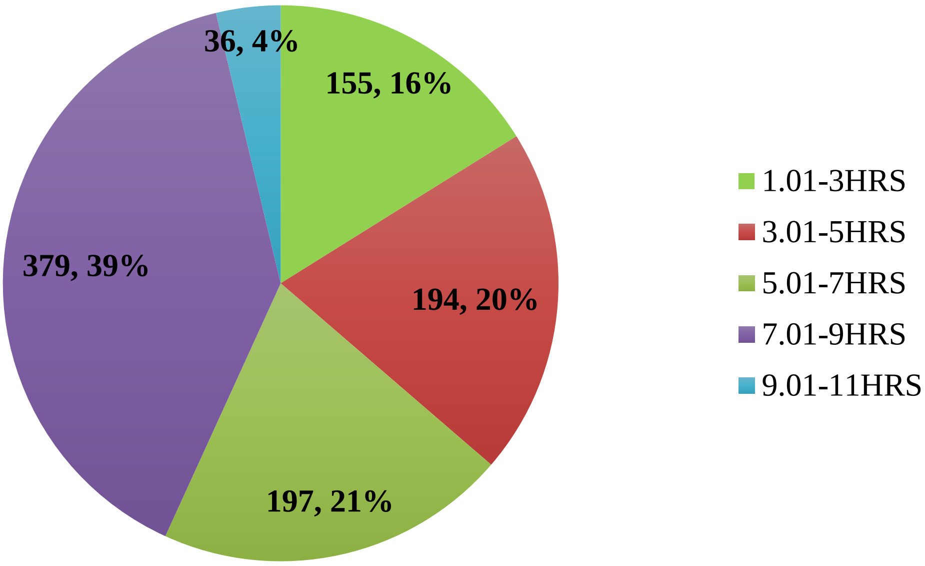
Farm Type. Figure 17 shows that the 519 (54%) recorded farm parcels were rainfed, and the 442 (46%) farm parcels were irrigated. Most of the farmer-respondents encounter difficulty in managing their rice farms during land preparation, crop establishment, irrigation, and pest management because of the disadvantages associated with rainfed farmlands. The findings confirm the study of Peng et al. (2022) that irrigated farmland allows greater production and better management more effectively.

Figure 18. Classification of Operation



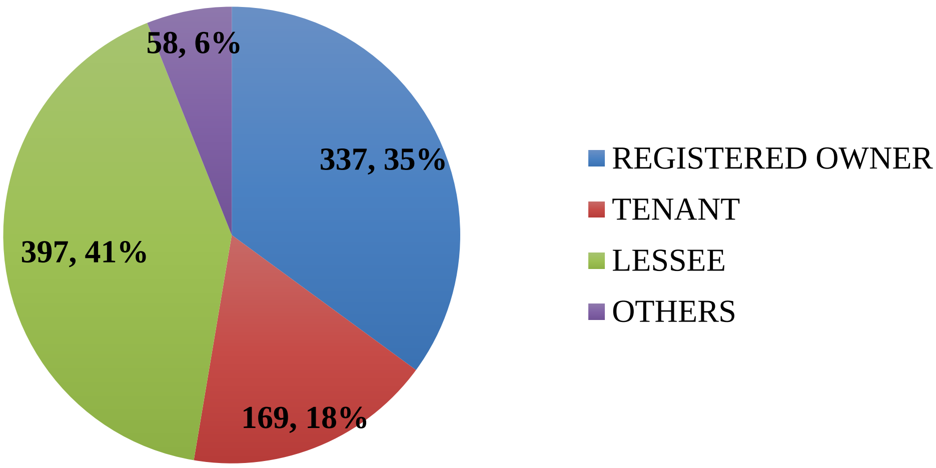
Classification of Operation. Figure 18 shows that majority of the farm parcels recorded were man-machine operated (957 farm parcels), and only 4 farm parcels were manually operated. This is due to labor scarcity wherein the farmers have to hire and utilize farm machinery to perform farm operations whether they have small or large farm size. This affirms the study of Lai et al. (2015) that the plentiful supply of farm labor is now more limited. On the other hand, Verma (2006) found that farm mechanization increases agricultural productivity and profitability on account of timeliness of operations, better quality of work and more efficient utilization of crop inputs. Farm mechanization resulted in less time for farm work.

Figure 19. On-farm Working Hours



On-farm Working Hours. Figure 19 shows that most of the farmer-respondents (379, 39%) spent 7.01-9 hours working on their farm, while 36 (4%) farmer-respondents stated that they do their farm activities for 9.01-11 hours. It is stated that the use of farm machinery facilitates faster completion of farm operations (Verma, 2006). However, the farm operations within the study area were not fully mechanized. Moreover, farm operations such as land preparation were influenced by other factors beyond the control of the farmer-respondents, such as water availability during land preparation and heat, so the farmer-respondents have to stretch their time to manage their farmlands.

Figure 20. Tenurial Status



Tenurial Status. Figure 20 shows that most of the recorded farm parcels (397, 41%) were tilled by farmer-lessees, and 58 (6%) farm parcels were operated by farmer-respondents who had a different type of settlement with the owner (heir, swap, salda, etc.). Regardless of tenurial status, the farmer-respondents utilized farm machinery. The only difference is that the landowners with larger farm size invested in farm machinery while the landowners with small farm sizes as well as the tenants and lessees rent farm machinery, and tend to buy small farm machinery and facilities for their farm operations which corroborates with the findings of Kalita (2018) that the larger farmers emerge as the market leader.

Land Fragmentation Index

Table 2. Average Land Fragmentation Index

Municipality	Land Fragmentation Index
Alilem	0.61
Banayoyo	0.81
Burgos	0.68
Cervantes	0.75
Galimuyod	0.75
Gregorio Del Pilar	0.60
Lidlidda	0.74
Nagbukel	0.56
Quirino	0.60
Salcedo	0.63
San Emilio	0.76
Sigay	0.65
Sugpon	0.57
Suyo	0.68
Average	**0.67**

Table 2 affirms that there is a higher degree of land fragmentation in the interior municipalities in the 2nd district of Ilocos Sur. This indicates that the farmers within the study area tilled a number of small, dis-connected planting plots for rice production which hampered the efficient utilization of farm machinery thereby increasing the total production cost due to extra labor cost, fuel inputs, extra time spent traveling from one plot to another, and heightened skill to accommodate machinery to small, irregularly shaped fields as cited by Lai et al. (2015) from the study of Bentley (1987). The findings corroborate with the study of Lai et al. (2015) and Wang et al. (2020) that land fragmentation decreases machinery use, and fragmented lands are associated with more labor devoted to farming that hinder the use of machinery sources.

Degree of Utilization of Farm Machinery/Equipment/Facility

Table 3 presents the degree of utilization of various farm machinery owned, managed, and utilized by the farmer-respondents for their rice farm operations.

Table 3. Degree of Utilization of Farm Machinery/Equipment/Facility

Machinery/Equipment/Facility Type	**Mean**	**Description**
Land Preparation		
Rotary Tilling Type (Walking-type Agricultural Tractor)	4.84	AU
Four-Wheel Tractor	4.67	AU
Multi-Cultivator	4.94	AU
Brush Cutter (weeder)	5.00	AU
Crop Establishment		
Walk-behind Rice Transplanter	2.00	SU
Water Pump	3.87	OU
Electric Water Pump	4.26	AU
Spraying and Granule Application (For fertilization/chemical application)		
Knapsack Sprayer	4.86	AU
Rechargeable Knapsack Sprayer	4.91	AU
Harvesting		
Combine Harvester	4.60	AU
Rice Reaper	1.00	NU
Preliminary Processing		
Rice Thresher (Engine-driven)	4.83	AU
Rice Thresher (Manual)	4.07	OU
Postharvest		
Grain Collector	5.00	AU
Portable Rice Mill	5.00	AU
Commodity Transport		
Farm Carrier (Trailer)	4.54	AU
Overall Mean	**4.27**	**AU**

Legend:

Statistical Limit	Descriptive Equivalent	Rating
4.21 – 5.00	Always utilized	AU
3.41 – 4.20	Often utilized	OU
2.61 – 3.40	Moderately utilized	MU
1.81 – 2.60	Seldom utilized	SU
1.00 – 1.80	Not at all utilized	NU

For land preparation, there were 4 types of machinery owned and utilized by the farmer-respondents. 187 farmer-respondents owned a walking-type agricultural tractor (rotary tilling type) that was rated as always utilized; 59 farmer-respondents owned a four-wheel tractor that was rated as always utilized; 18 farmer-respondents owned a multi-cultivator that was rated as always utilized; and only 5 farmer-respondents owned a brush cutter that was rated as always utilized. The results revealed that land preparation was done solely with the use of machinery operated by man. The findings agree with the study of Bautista et al. (2017) that hand tractors were utilized more because it can do plowing, harrowing, leveling, and even hauling of farm inputs and outputs. Moreover, it contradicts the findings of Bautista et al. (2017) that tractor tended to be very seldom used in the farm because of limited access roads.

For crop establishment, there were 3 types of machinery owned and utilized by the farmer-respondents. Only 1 farmer-respondent managed a walk-behind type rice transplanter that was issued to the Farmers' Association which was rated as seldom utilized; 316 farmer-respondents owned a water pump that was rated as often utilized; and 45 farmer-respondents owned an electric water pump that was rated as always utilized. It was found that rice transplanting was done manually due to the fact that there was a lack of training and technical know-how on the operation of a walk-behind type rice transplanter, and also the difficulty in seedling preparation that hampered the adoption and utilization of the machinery. On the other hand, most of the farmer-respondents relied on rainwater during wet season, when the rainwater did not suffice the crop water requirement during the growth stage of the rice crop that was the only time that they used a water pump as an alternative, some utilized water pumps during sowing only, and other used it during the dry-season. Moreover, it was revealed that electric water pump was utilized more for crop irrigation due to its cost-efficiency, because electrical power is cheaper than fuel. The surveyed data confirms the findings of Bautista et al. (2017) that seedling preparation and pulling, and transplanting was done manually. Furthermore, the results disagree with Bautista et al. (2017) who stated that there is a low utilization of shallow tube wells due to high cost of fuel.

For the spraying of pesticides and foliar fertilizers, there were 2 types of machinery owned and utilized by the farmer-respondents. 223 farmer-respondents owned a knapsack sprayer that was rated as always utilized; and 289 farmer-respondents owned a rechargeable knapsack sprayer that was rated as always utilized. The results have shown that chemical and foliar fertilizer application was done solely with the use of knapsack sprayers and rechargeable knapsack sprayers.

For harvesting, there were 2 types of machinery owned and utilized by the farmer-respondents wherein 6 farmer-respondents owned a combine harvester that was rated as always utilized; and there was only 1 farmer-respondent who owned a rice reaper that was rated as not at all utilized. It was found that combine harvesters were utilized more due to its field efficiency by combining multiple operations such as gathering, transporting, reaping, threshing, cleaning, and bagging making harvesting operations convenient. On the other hand, rice reaper was not used because it required more labor force than the combine harvester thereby increasing the total production cost. Generally, harvesting was done either manually or with the use of a farm machinery.

For preliminary processing, there were 2 types of machinery owned and utilized by the farmer-respondents. 29 farmer-respondents owned an engine-driven rice thresher that was rated as always utilized; and only 12 farmer-respondents owned a manual rice thresher that was rated as often utilized. It was revealed that the farmer-respondents utilized the aforementioned machinery for their very small farm size, and farms located at the mountainous part where the combine harvesters cannot access. Furthermore, both farm machinery was utilized in order to preserve the rice straw as forage for livestock. The results agree with the findings of Bautista et al. (2017) that axial flow threshers were utilized due to its suitability to enter inner rice fields with limited road access because it can be pulled by carabao.

For postharvest, there was only 1 farmer-respondent who owned a grain collector that was rated as always utilized; and only 1 farmer-respondent who owned a portable rice mill that was rated as always utilized. The results have shown that the units were used because of its suitability to the rural areas, ease of operation, ease of transport, and readily available for household use.

For commodity transport, 12 farmer-respondents owned a farm carrier (trailer) that was rated as always utilized due to its capacity to transport tons of rice grains harvested from the farm to the farmer's house.

Comparative Analysis on the Cost of Production of Manually Operated vs Man-Machine Operated Rice Farms based on the Last Cropping Season along with the Price of Inputs

Table 4. Average Cost of Production Per Hectare of a Man-Machine Operated Rice Farm and Manually Operated Rice Farm

Municipality	Average Cost of Production/Hectare	
	Man-Machine Operated	Manually Operated
Alilem	Php 65,754.98	
Banayoyo	Php 57,190.68	
Burgos	Php 66,676.88	
Cervantes	Php 59,924.30	
Galimuyod	Php 71,245.11	
Gregorio Del Pilar	Php 66,938.25	
Lidlidda	Php 66,198.73	
Nagbukel	Php 35,189.63	
Quirino	Php 86,668.48	
Salcedo	Php 68,687.94	
San Emilio	Php 57,791.18	
Sigay	Php 52,046.42	
Sugpon	Php 67,746.35	
Suyo	Php 50,850.33	Php 16,368.42

**458 farmer-respondents for man-machine operated rice farms*
**1 farmer-respondent for manually operated rice farm*

Cognizant of all the induced costs on rice production, it was found that the cost of production per hectare of rice for man-machine operated farms differ for each municipality that ranged from Php 35,189.63 (Nagbukel) to Php 86,668.48 (Quirino) (Table 4). Moreover, the recorded cost of rice production per hectare for a manually-operated rice farm from a lone farmer-respondent in Suyo, Ilocos Sur was Php 16,368.00. The factors that affected the varied cost of production include land rental fees, farm inputs such as fertilizer cost, and machine rental (per square meter, per hour or per day – irrespective of farm size, per year).
The comparative analysis using Analysis of Variance (ANOVA) was not employed in this study because there was only one farmer-respondent who utilized manual operation for his farm activities which is not sufficient to conduct statistical analysis due to non-normal distributions of the sample size. The surveyed data only implies that despite of the small holding size and fragmented farmlands of the farmer-respondents they opted to utilize farm machinery for their farm operations.

Relationship of the Demographic Profile to the Degree of Utilization of Farm Machinery

Table 5. Relationship of the Demographic Profile to the Degree of Utilization of Farm Machinery:
Pearson Correlation Coefficient

	Degree of Utilization
Age	-0.004
No. of Household Members	0.031

The age and the number of household members of the farmer-respondents are not correlated with the degree of utilization of the farm machinery. The results justified that the age whether young or old, and the number of household members whether larger or smaller, did not influence the level of utilization of the farm machinery. This contradict the findings of Apiors (2016) which stated that age is correlated to machinery access and higher productivity, indicating that older farmers may have enough wealth due to longer period of saving and better network. These enable easy access to resources compared to younger farmers. Furthermore, the results differ with the findings of Ma et al. (2018) that the household size have a negative and statistically significant impact on machinery use, indicating that the larger households potentially have a greater supply of family farm labor, which leads to less need for labor-saving technologies such as machinery.

Table 6. Relationship of the Demographic Profile to the Degree of Utilization of Farm Machinery: Chi-Square Tests

	Degree of Utilization
Sex	4.29
Marital Status	15.82*
Educational Background	22.06
Member of Association/Organization	0.68

**indicates significance at 5% level*

Table 6 discloses that the sex, educational background, and membership to association/organization of the farmer-respondents were statistically insignificant to the degree of utilization of farm machinery. However, there is a significant relationship between the marital status and the degree of utilization of farm machinery. It was revealed that the sex whether male or female, educational background (number of years in education), and membership to association/organization of the farmer-respondents did not affect the farm machinery utilization. It was also found that the married farmer-respondents utilized machinery services more than the single and the widowed farmer-respondents. Because the single and widowed farmer-respondents only tilled a small farm area that can be easily and efficiently managed by few farm laborers with just a minimal use of small farm machinery such as the walking-type agricultural tractor or multi-cultivator. On the other hand, the married farmer-respondents have a larger farm area which required more farm laborers that demanded higher labor price; for the sake of cost efficiency, machinery efficiency, and convenience they tended to hire farm machinery to do farm operations, contract type, which in return saved labor costs and extra time attending to the needs of the farm laborers, and the expenses that was supposed to be paid for the farm laborers was saved for the other non-farm expenses of their family. Therefore, the results accept the alternative hypothesis that there is no significant relationship between the demographic profile and the degree of utilization of farm machinery in terms of age, number of household members, sex, educational background, and membership to association/organization. However, in terms of marital status, the alternative hypothesis was rejected. The results disagree with the study of Ma et al.

(2018) who found that gender has a negative and statistically significant impact on machinery use, which suggests that relative to male household heads, female household heads are more likely to use farm machines. Which also contradicts with the findings of Dalman et al. (2023) that higher levels of education correlate with higher productivity and machinery use. Furthermore, it differs with the findings of Zhang et al. (2020) that cooperative membership has a positive effect on the technology adoption, significantly in terms of the number of postharvest technologies adopted. On the other hand, the findings support the study of Liu et al. (2013) that an increased labor price, increases the farmers' adoption of large machinery, which is also consistent with the study of Onomu and Aliber (2021) that tractor use appears to have a relationship with marital status, with almost all tractor users in their study area were married.

Relationship of the Degree of Utilization of the Farm Machinery to the Cost of Production

Table 7. Relationship of the Degree of Utilization of the Farm Machinery to the Cost of Production

	Degree of Utilization
Cost of Production/Ha	0.064993

The results accepted the alternative hypothesis that there is no significant relationship between the degree of utilization of farm machinery and cost of production. It was revealed that the degree of utilization of farm machinery was not correlated with the cost of production per hectare, indicating that the degree of utilization of the farm machinery whether it was always utilized or not did not affect the cost of production per hectare of rice. The result contradicts the study of Tang et al. (2018) which stated that agricultural services can help improve cost efficiency, thus contributing to cost saving.

Econometric Impact of Land Fragmentation

Table 8 investigates the correlation of land fragmentation, direct inputs, total cost of production, holding size, and number of household members to crop productivity.

Table 8. Econometric Impact of Land Fragmentation

	Crop Productivity (ton)
Fragmentation index	-0.37*
Seeds (kg)	0.59*
Fertilizers (kg)	0.74*
Machine use (Php)	0.82*
Total cost of production (Php)	0.81*
Holding size (ha)	0.81*
No. of household members	0.07

**indicates significance*

There is a negative but significant correlation between crop productivity and land fragmentation which indicates that land fragmentation inversely affects crop productivity. That means the higher the degree of fragmentation, the lower the crop productivity. The result reaffirms that there is an increased number of disconnected planting plots with very small plot size in the study area which is associated with more labor force that hampers the efficient use of farm machinery thereby increasing the total production cost due to extra labor cost, fuel inputs, extra time spent traveling from one plot to another, and heightened skill to accommodate machinery to small, irregularly shaped fields; reduced rice productivity; and low farming income. Hence, the land fragmentation is a limiting factor to a highly mechanized agriculture in the country, the efficient utilization of agricultural machinery, and the proper distribution and utilization of farm inputs which diminished rice crop productivity in the area that generated low profit. One of the reasons for the inefficient distribution of farm inputs was fertilization wherein soil fertility gradient differs per farm parcel indicating that if the farmer has non-contiguous land plots, the soil fertility is non-uniform thereby determining the requisite amount of fertilizer for each farm parcel will be difficult but considered as a key to plentiful crop production as cited by Singh et al. (2020) in the study of Kimetu et al., (2004), and Tariq et al. (2007). The findings corroborate with the study of Lai et al. (2015) and Wang et al. (2020) that land fragmentation decreases machinery use, and fragmented lands are associated with more labor devoted to farming that hinder the use of machinery sources. The results are also similar to the findings of Patrik Sundqvist and Lisa Andersson (2006) that there is a negative correlation between the fragmentation index and land productivity because fragmented land holdings increase transport costs; management, supervision and securing of scattered plots is difficult, time consuming, and costly; small and scattered plots hamper the use of machinery such that operating machines and moving them from one field to another in small fields can cause problems. This is consistent with the findings of Lai et al. (2015) on the effects of land fragmentation on machinery use and on crop production which the results indicated that consolidating an average farm of 0.31 hectares from 2.28 plots to one plot increases machinery use by about 10%. Further, a 10% increase of machinery use increases crop production between 0.5% and 1%. Also, land fragmentation leads to lower productivity and higher cost and larger plots are associated with higher profits per acre.

There is a positive and significant correlation between crop productivity and the direct inputs, indicating that as the direct input increases, the crop productivity also increases. It was revealed that the farmer-respondents with larger holding size invested more on seeds, fertilization, and efficient machinery use which generated high crop productivity that resulted to high profit. On the contrary, the respondents with small, non-contiguous land plots who sowed more seeds, and applied more fertilizers above the requirement per farm area did not increase their productivity but only added their cost of production which resulted to cost inefficiency and low economic profitability. Hence, it is crucial to know the required amount of input per farm area, and per growth stage of rice for a better crop yield thereby avoiding unnecessary expenditures to reduce production cost. To promote effective and efficient use of farm inputs, the proper technology on rice crop production should be followed such as the seed requirement per hectare, spacing of transplanted rice, and fertilization rate with the right element, right amount, and right timing of application. The results were consistent with the findings of Liu et al. (2013) and Jette-Nantel, Hu, and Liu (2014) that large machinery is associated with higher productivity on larger plots, which may indirectly suggest that land fragmentation may hamper the diffusion of larger machinery.

There is also a positive and significant correlation between crop productivity and total cost of production, indicating that as the total cost of production increases, the crop productivity also increases. It was found that the farmer-respondents with small, disconnected planting plots who spent less on the total production cost generated a lower crop yield and in return gained low profit. Whereas the farmer-respondents with compact and larger farm area invested more on quality seeds, proper land preparation, crop establishment, fertilizer application, irrigation, pest management, harvesting, and postharvest handling that resulted to a higher total production cost but obtained a higher crop productivity and increased profit.

There is also a positive and significant correlation between crop productivity and holding size. This indicates that as the holding size increases, the crop productivity also increases. It was revealed that larger

holding size was associated with the intensive and efficient use of farm machinery, better farm management, and reduced total production cost, which yielded higher rice production that generated higher farming profit. On the contrary, a small holding size caused reduced productivity and low economic profitability. The result corroborates with the study of Apiors (2016) that the land size cultivated positively contributes to productivity of rice farms with respect to mechanization. The results also support the findings of Onomu and Aliber (2021) that the higher the area cultivated, the greater the likelihood of the farmer using labor-enhancing technology such as the tractor. An increase in farm size will likely result in increased farm output, which will positively influence prices, incomes, and farm employment.
The number of household members do not correlate with the crop productivity, indicating that whether the household size is larger or smaller it does not affect the economic profitability of rice production.

4. Conclusions

Based from the preceding results of the study, the following conclusions were drawn:

1. Majority of the farmer-respondents were IP members, male, in their mature working age, married, have 4-6 household members, finished high school, members of an association/organization, had a farming income below poverty threshold level, had 1 farm parcel, had farms located within their barangay, had a subsistence farm area, had a rectangular shaped plots, had farm plots 0-4km away from their house, had a rainfed farm type, farmlands were man-machine operated, spent 7.01-9.0 hours working on-farm, and were farmer-lessees.
2. The farmer-respondents within the study area tilled a number of small, disconnected planting plots for rice production which hampered the efficient utilization of farm machinery, and increased production cost.
3. The overall degree of utilization of the rice farm machinery owned, managed, and utilized by the farmer-respondents was always utilized. One of the reasons why the walk-behind type rice transplanter was seldom utilized was the lack of knowledge and training on its operation, and the difficulty of seedling preparation.
4. The comparative analysis using ANOVA was not employed in this study because there was only one farmer-respondent who utilized manual operation for his farm activities which is not sufficient to conduct statistical analysis due to non-normal distributions of the sample size.
5. The age, number of household members, sex, educational background, membership to association/organization do not influence the degree of farm machinery use. However, there is a significant relationship between marital status and degree of utilization of the farm machinery with respect to holding size.
6. The degree of utilization of farm machinery does not affect the cost of rice production per hectare.
7. For the econometric impact, crop productivity and economic profitability of rice production was greatly affected by land fragmentation which also has a direct effect on the level of use of direct inputs, total production cost, and holding size. On the other hand, the number of household members do not affect crop productivity and farm profit. Hence, land fragmentation deters economic development.

5. Recommendations

Cognizant of the foregoing conclusions, the following recommendations are forwarded:

1. The development planners or policymakers of agricultural agencies should: formulate strategies to encourage the rural youth to engage in farming; devise a capacity building activity to promote and

enhance the financial management skills of farmers; develop and establish irrigation systems to support crop water requirement and better farm management.

2. The development planners or policymakers of agricultural agencies should formulate strategies to increase the holding size and decrease the magnitude of farm parcels to reduce land fragmentation such as promote land consolidation to maximize the efficiency of machinery use and land productivity. Also, the research institutes may develop a village-type machinery suitable for small-scale farms.
3. The development planners or policymakers of agricultural agencies within the study area may use this study as reference for their machinery-related programs and projects to complement the farm profile of the farmers and promote efficient machinery utilization; furthermore, the use of crop establishment machinery should be encouraged.
4. The government may allocate fund for the purchase and distribution of preliminary processing facilities, postharvest facilities, and commodity transport vehicle for the rural farmers; and may propose a standard rate of land rental fees, and machinery rental fees; and likewise, may allocate funds to subsidize the farm inputs of the rice farmers.
5. Similar studies on the relationship of demographic profile, degree of utilization of farm machinery, and other variables should be conducted to cover the other district of Ilocos Sur.
6. The development planners or policymakers of agricultural agencies should formulate approaches that would enhance better utilization of agricultural machinery, and conduct training on the utilization and operation of modern agricultural machinery.
7. Similar studies on the relationship of the degree of utilization of farm machinery to the cost of production should be conducted to cover the other district of Ilocos Sur.
8. Land consolidation must be reinforced to lessen the cost of production, increase the efficiency of machinery use, increase rice production, and increase rice farming profit.
9. Similar studies on the econometric impact of land fragmentation should be conducted to cover the other district of the province of Ilocos Sur.

6. Appendix

Appendix 1. Summary of Data

Municipality	Total Number of RSBSA Registered Rice Farmers	Total Area Planted with Rice (HA)	Total Number of Parcels	Average Number of Parcels/Farmer	Average Holding Size (HA)/Farmer	Average Farm Size (HA)/Parcel
Alilem	1588	750.00	5678	4	0.47	0.13
Banayoyo	964	635.00	4134	4	0.66	0.15
Burgos	2100	1246.00	8440	4	0.59	0.15
Cervantes	2049	1238.43	4613	2	0.60	0.27
Galimuyod	1184	864.00	4456	4	0.73	0.19
Gregorio del Pilar	772	475.29	4049	5	0.62	0.12
Lidlidda	685	480.00	1385	2	0.70	0.35

Nagbukel	1122	720.00	4117	4	0.64	0.17
Quirino	2203	890.75	7480	3	0.40	0.12
Salcedo	1335	957.49	5227	4	0.72	0.18
San Emilio	1386	1170.65	9441	7	0.84	0.12
Sigay	432	411.83	1952	5	0.95	0.21
Sugpon	681	416.00	3008	4	0.61	0.14
Suyo	1541	811.43	3629	2	0.53	0.22
**Source of data: DA-RFO 1 & LGU*						

Appendix 2. The Average Crop Productivity Per Hectare Per Municipality

Municipality	**Crop Productivity in Ton/Ha**
Alilem	3.67
Banayoyo	3.68
Burgos	4.65
Cervantes	3.57
Galimuyod	3.98
Gregorio Del Pilar	3.45
Lidlidda	3.66
Nagbukel	2.85
Quirino	5.29
Salcedo	4.90
San Emilio	3.19
Sigay	3.10
Sugpon	3.27
Suyo	3.92
Average	**3.80**

Chi-Square Tests

Appendix 3. Sex vs Degree of Utilization

O	E	(O-E)	(O-E)2	(0-E)2/E
4.00	3.51	0.49	0.24	0.07
0.00	0.49	-0.49	0.24	0.49
3.00	3.51	-0.51	0.26	0.08
1.00	0.49	0.51	0.26	0.54
21.00	19.33	1.67	2.80	0.14
1.00	2.67	-1.67	2.80	1.05
53.00	50.08	2.92	8.55	0.17
4.00	6.92	-2.92	8.55	1.23
324.00	328.57	-4.57	20.87	0.06
50.00	45.43	4.57	20.87	0.46
				4.29

Appendix 4. Marital Status vs Degree of Utilization

O	E	(O-E)	(O-E)2	(0-E)2/E
0.00	0.45	-0.45	0.20	0.45
4.00	3.43	0.57	0.33	0.10
0.00	0.12	-0.12	0.01	0.12
1.00	0.45	0.55	0.30	0.66
2.00	3.43	-1.43	2.03	0.59
1.00	0.12	0.88	0.77	6.34
4.00	2.49	1.51	2.29	0.92
16.00	18.84	-2.84	8.09	0.43
2.00	0.67	1.33	1.77	2.64
10.00	6.33	3.67	13.47	2.13
45.00	47.97	-2.97	8.79	0.18
1.00	1.70	-0.70	0.50	0.29
37.00	42.28	-5.28	27.86	0.66
327.00	320.34	6.66	44.37	0.14
10.00	11.38	-1.38	1.91	0.17
				15.82*

Appendix 5. Educational Background vs Degree of Utilization

O	E	(O-E)	(O-E)2	(0-E)2/E
0.00	0.32	-0.32	0.10	0.32
2.00	0.37	1.63	2.65	7.09
0.00	1.90	-1.90	3.61	1.90
2.00	1.21	0.79	0.63	0.52
0.00	0.20	-0.20	0.04	0.20
0.00	0.32	-0.32	0.10	0.32
1.00	0.37	0.63	0.39	1.05
3.00	1.90	1.10	1.21	0.64
0.00	1.21	-1.21	1.45	1.21
0.00	0.20	-0.20	0.04	0.20
2.00	1.77	0.23	0.05	0.03
0.00	2.05	-2.05	4.21	2.05
12.00	10.45	1.55	2.40	0.23
7.00	6.63	0.37	0.13	0.02
1.00	1.10	-0.10	0.01	0.01
5.00	4.57	0.43	0.18	0.04
3.00	5.32	-2.32	5.37	1.01
33.00	27.08	5.92	35.07	1.30
16.00	17.19	-1.19	1.41	0.08
0.00	2.84	-2.84	8.09	2.84
30.00	30.02	-0.02	0.00	0.00

37.00	34.89	2.11	4.47	0.13
171.00	177.67	-6.67	44.49	0.25
114.00	112.77	1.23	1.52	0.01
22.00	18.66	3.34	11.16	0.60
				22.06

Appendix 6. Member of Association/Organization vs Degree of Utilization

O	E	(O-E)	(O-E)2	(0-E)2/E
4.00	3.92	0.08	0.01	0.00
0.00	0.08	-0.08	0.01	0.08
4.00	3.92	0.08	0.01	0.00
0.00	0.08	-0.08	0.01	0.08
22.00	21.57	0.43	0.18	0.01
0.00	0.43	-0.43	0.18	0.43
56.00	55.89	0.11	0.01	0.00
1.00	1.11	-0.11	0.01	0.01
366.00	366.70	-0.70	0.49	0.00
8.00	7.30	0.70	0.49	0.07
				0.68

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