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Assessment on the Level of Mechanization in the Rice Production and Post-Production Systems in Surigao Del Sur

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Abstract: *Agricultural mechanization has emerged as a critical factor in transforming modern farming practices, as it addresses challenges and promotes efficiency and sustainability in a growing global population and increased food demand. This paper assessed the level of mechanization (hp/ha) in rice production and post-production systems in Surigao del Sur. Interviews were conducted with 95 farmers who are members of the Registry System for the Basic Sectors in Agriculture (RSBSA). Cost and return analysis shows a profit-cost ratio of 0.52. Moreover, the level of mechanization of the province, as computed using the Modified Agricultural Mechanization Index (MAMI) equation, is 3.80 hp/ha for the mechanical (combined harvester) method and 3.09 hp/ha for manual harvesting, which is still significantly low. It is justifiable since most agricultural operations, especially planting and crop care management, are performed manually. Land preparation and harvesting, mostly done mechanically, have the highest mechanization indices.*

Keywords: Rice Mechanization, Level of Mechanization, Rice Production, Post-Production

1. INTRODUCTION

Agricultural mechanization is crucial in timely and efficient farm operations [1]. It involves using tools, machinery, and equipment as essential inputs in agricultural production systems. This technology helps improve agricultural productivity by minimizing time-consuming tasks, addressing labor shortages, and creating new job opportunities. Mechanical technology, such as tractors and implements, enhances human labor productivity, surpassing what can be achieved manually. Filipino farmers are becoming increasingly aware of the benefits of agricultural mechanization.

However, the agriculture sector in the Philippines still faces challenges [2] [3] [4]. Although the country has progressed in agricultural mechanization, the Philippine Center for Postharvest Development and Mechanization (PhilMech) still considers the level low. The Philippine government recognizes agriculture as a crucial livelihood source for farmers and actively promotes mechanization to increase productivity, reduce losses, and minimize labor requirements.

Agricultural infrastructure and mechanization technologies are essential for development [5]. Hence, the agricultural sector prioritizes developing and acquiring farm machinery and equipment to support these goals.

However, a lack of current data on mechanization levels, especially in Surigao del Sur, hampered the government's and involved organizations' efforts to develop more effective programs and policies for agricultural modernization and productivity. Thus, this study calculates the level of mechanization in terms of hp/ha and power source. In addition, this study determined the socio-demographic profile of rice farmers in selected municipalities in Surigao del Sur and performed cost and return analysis of rice production systems.

2. METHODOLOGY

The process flow of the study is shown in Figure 1. Qualitative and quantitative research approaches were applied in this study. The primary data was obtained using a survey questionnaire. In analyzing the data, descriptive measurements such as sum, percentage, and mean were applied to describe and evaluate the variables.

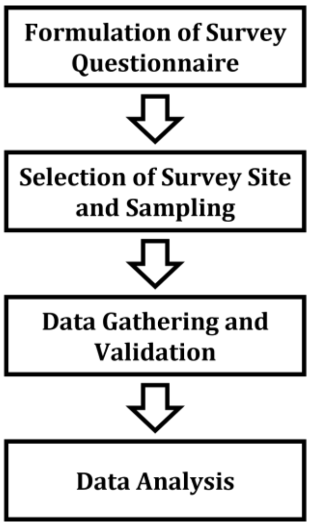

Figure 1. Process flow of the study

2.1 Formulation of Survey Questionnaires

The questionnaire used in this study to gather the primary data was based on and developed by [6], whose findings align with this research's objectives. The survey questionnaire was tested in Butuan City, municipalities of Carmen, Surigao del Sur, and Remedios T. Romualdez, Agusan del Norte. This was performed to verify the questionnaire's validity.

2.2 Selection of Survey Sites and Sample Sizes

The number of cities and municipalities surveyed and the total number of samples collected from the entire province were all determined in conjunction with the DA-Caraga. Surigao del Sur Province was categorized by rice production volume, ranging from small to medium to large.

Table 1. Sampling and Categorization of Sample Site

	Municipality/City	Total Area (ha)
Large	San Miguel	4,743.90
	Cantilan	2,115.81
Medium	Bislig	2,023.58
	Tagbina	1,291.52
Small	Tandag	1,065.56
	Madrid	674.89
Total		11,915.26

Source: DA-Caraga

The farmers' sample size was determined using Cochran's equation. The Cochran formula is used to compute the sample size necessary to achieve the appropriate level of precision, confidence, and the estimated proportion of the attribute in the population. The Cochran formula is ideal for large populations [7]. This study employs a 95% confidence level, implying that the calculated sample is certain 95% of the time, with a 2% margin of error and population proportion of 0.99.

Furthermore, a stratified random sampling method was used. The stratified random sampling approach narrows the gap between various types of individuals by classification, which is beneficial to obtaining representative samples and reducing sample size. It is a frequently applied method for approximation query processing [8] [9].

Table 2. Distribution of Sample Size

Municipality/City	Number of Respondents
San Miguel	38
Cantilan	17
Bislig	16
Tagbina	10
Tandag	9
Madrid	5
Total	**95**

2.3 Data Collection

The respondents were interviewed face-to-face and answered the survey questionnaires. The data collection started on September 12, 2022, and was finished on October 26, 2022.

2.4 Data Analysis

Microsoft Excel was utilized for data input, analysis, and processing. It was also used to create tables and graphs. The subsequent sections detail the methods for achieving the specific objectives.

2.4.1 Demographic Profile of the Respondents

The socio-demographic profile of rice producers was presented through graphs and table representations utilizing Microsoft Excel.

2.4.2 Level of Mechanization

The level of mechanization was determined based on a study by [6]. The Modified Agricultural Mechanization Index (also known as the MAMI) was used to calculate the hp/ha index. The parameters that were considered in calculating the mechanization index are the total horsepower generated by human, animal, and mechanical power used in various operations during rice production; the total area planted or farmed for rice in the province; the windows of operation; the daily operating hours of the power source; and the power source for each operation.

$$MAMI = \frac{\Sigma\,(HP_s \times N_s + N_w \times HP_m)}{\Sigma\,A_t} \tag{1}$$

$$A_t = C \times t \times W \tag{2}$$

where:

MAMI	= Modified Agricultural Mechanization Index of the operation, hp/ha
HP_s	= Power source, hp
N_s	= number of sources of power
N_w	= number of operators or worker
HP_m	= power of man, hp
A_t	= total coverage area, ha
t	= daily operating hours of the power source, h
W	= window of operation, days
C	= total actual field capacity of the power source, ha/hr

The level of mechanization for each farm operation of rice production and postproduction systems was calculated based on using different power sources. The level of mechanization was calculated using equations 3 and 4 [18].

$$P_o = \left(\frac{N_f}{N_t}\right) \times 100 \tag{3}$$

where:

P_o	= Mechanization Level per operation (by type of farmer's utilization)
N_f	= No. of farmers using the power source
N_t	= Total number of respondents

For each farm operation with rice production and postproduction systems, the level of mechanization was calculated based on the area covered by the various technologies used by the farm (or type of power source). The level of mechanization was calculated using the following equation.

$$P_s = \left(\frac{A_f}{A_t}\right) \times 100 \quad (4)$$

where:

P_s = Mechanization Level per operation (by type of power source)
A_f = Farm area using the power source
A_t = Total coverage area

2.4.3 Cost and Return Analysis

The study examined the production cost and return for rice production and post-production. Two selling conditions, wet palay (farmer's level) and milled rice (miller's level), were considered, with distinct production costs due to the different operations involved. Cost analysis was conducted for two planting methods: broadcasting and transplanting. The production costs for each operation, from land preparation to milling, were calculated for various power sources used by farmers. Net return was determined by subtracting total costs from gross returns, and the net profit-cost ratio was computed using a specific equation for cost and return analysis.

3. RESULTS AND DISCUSSION

3.1 Demographic Profile of the Farmer Respondents

Ninety-five farmer respondents from different cities/municipalities of the Province of Surigao del Sur were interviewed to gather the primary data needed in this study. All of which were members of the Registry System for Basic Sectors in Agriculture (RSBSA).

3.1.1 Sex of Rice Farmer Respondents

Table 3 shows that the majority of the workforce in the rice production industry in the province was composed of male farmers, with 61% male respondents. This is expected because males do most farm operations like land preparation, seedbed preparation, and irrigation canal maintenance [10]. Subsequently, 39% of the respondents were female. This implies that females in the province of Surigao del Sur are engaging in agriculture. However, they have specific responsibilities to fulfill. Women are essential in planting, transplanting, manual weeding, and manual harvesting.

3.1.2 Age of Rice Farmer Respondents

Data shows that the ages of the rice farmers in the Province ranged from 23 to 85 years old. It was found that the age of rice farmers negatively affects yield [11]. Farmers aged 40-49 had an average yield of 4.55 tons/ha, 50-59 had 4.68 tons/ha, and those below 30 had the highest average yield of 5.55 tons/ha. Farm experience and age both impact yield and production [12]. Despite being predominantly elderly, rice farmers expressed their desire to continue farming due to limited alternatives and additional income sources for supporting their families as young individuals pursue education or work in urban areas.

Table 3. Demographic Profile of the Respondents

Variables	Distribution
Sex	
Male	61%
Female	39%
Age	
<30	2%
30-39	20%
40-49	26%
50-59	24%
60-69	16%
>70	12%
Educational Attainment	
Elementary Undergraduate	11%
Elementary Graduate	17%
High School Undergraduate	15%
High School Graduate	23%
Vocational Graduate	3%
College Undergraduate	12%
College Graduate	19%
Main Occupation	
Government Official/Employee	5%
Full-time Farmer	92%
Others	3%

3.1.3 Educational Attainment of Rice Farmer Respondents

Most of the rice farmer respondents are high school and elementary graduates, with only 19% of the farmers finished college. In addition, farmers with higher education levels, such as college graduates or undergraduates, achieve an average yield of 5.24 tons/ha, while those with a high school education achieve an average yield of 4.82 tons/ha. Farmers with only an elementary education achieve an average yield of 3.91 tons/ha. These findings imply that higher levels of education correlate with higher productivity. Previous studies have also emphasized the importance of education in acquiring new information and seeking technology suited to production constraints. A significant challenge to technology adoption and management is the lack of knowledge about new technologies. Education serves as the foundation for understanding the significance of machinery in agriculture and appreciating how it contributes to increased productivity, efficiency, and sustainability in the sector [13] [14].

3.1.4 Main Occupation of Rice Farmer Respondents

Table 3 shows that most farmer respondents considered farming their primary occupation. This is because most rice farmers in Surigao del Sur did not pursue higher education, as shown in the table. Subsequently, a small percentage of rice farmers that are employed or working in the government only do farming after office hours or on weekends. Other occupations include construction workers, drivers, and tailors. Farmers often have another job aside from farming to ensure financial stability, as farming can be unpredictable and subject to risks, to supplement their income due to limited earnings from farming alone and a lack of agricultural subsidies and support in their municipality.

3.3 Cost and Return Analysis

The costs in the rice production system are mostly comprised of rental fees for land, livestock, equipment, and machinery; utility expenditures, including irrigation; and agricultural labor. Food is not included in the wage, and agricultural inputs such as seeds, fertilizer, herbicide, insecticide, molluscicide, rodenticide, fuel, and oil are among the specified information. Rental fees were paid in cash or in kind. On the other hand, farm laborers were either family members or hired laborers.
Table 4 summarizes the different costs associated with the various rice production operations. The labor costs comprised paid work and labor provided by family members and fees for renting tools and agricultural equipment. Inputs include fertilizer, herbicide, fuel, and oil for the engine, seeds, and food.

Table 4. Unit costs of different activities in Rice production

Items	**Unit Cost**
Family/Hired Labor	P 300 – P 500/day
Man-Animal Fee	P 500 – P 800/day
Tractor	P 200 – P 350/hour
Irrigation Fee	P 500/cropping
Planting-Harvesting Fee	P 6000 – P 7,500/ha
Harvesting Fee	8% - 10% of the harvested grains
Hauling Fee	P 20 - P 50/sack
Drying Fee	P 25 - P 35/sack
Milling Fee	P 2 - P 3.50/kilo
Interest Rate	5% - 10%/cropping

Table 5 shows the gross income and return derived from rice production systems. The miller received the largest share (45.29%), while the farmer level has only 34.19% of profits generated in the rice production value chain. However, when milled rice is marketed in comparison to wet palay, there is a marginal increase in profit.

Table 5. Gross income and return derived from rice production systems.

Product (Stakeholder)	**Wet Palay** (Farmer's level)	**Milled Rice** (Miller's level)
Amount (Php/kg)	15.83	36
(Php/ha)	73,129.78	94,274.01
Total cost (Php)	48,251.00	51,575.00
Net Return (Php)	24,878.78	42,699.05
Share (%)	34.19	45.29

The cost and return analysis are shown in Table 6. The average farmgate price of wet palay is Php 15.83 per kg. This would yield a gross return of Php 73,129.78 per hectare (ha). On the other hand, the total production cost per ha is Php 48,251.00. Therefore, the net return will amount to Php 24,878.78 per ha. This would give a profit-cost ratio of 0.52. This means that rice cultivation yielded a return on investment of 0.52 pesos for every peso invested. This may look good on paper, but this does not mean that rice farming is profitable. Rice production every season would typically last four months. Since the net return for each rice farmer is only Php 24,878.78, it means that a rice farmer tilling one hectare would only get Php 6,219.70 per month. High production cost, together with small farm sizes, consumes most of the returns of each rice farmer [15].

Table 6. Cost and Return Analysis

Item	**Amount** Php/ha	Php/kg
Gross Return	73,129.78	15.83
Total Cost	48,251.00	10.44
Inputs	15,310.00	3.31
Labor/rentals	30,941.00	6.70
Land rental	-	
Interest on crop loan and capital	2,000.00	0.43
Net Returns	24,878.78	5.39
Net Profit-Cost Ratio	**0.52**	**0.52**

3.4 Determination of hp/ha for Rice in the Province of Surigao del Sur

The province of Surigao del Sur is known for its production of palay, which is the principal crop farmed there. It encompasses a total land area of 523,050 ha, which is equivalent to 5,230.5 square kilometers, and it accounts for 22.75% of the total land area in the Caraga region. A further 214,032 ha of the province's total land area is designated for use in agricultural production.
Most of the procedures involved in rice production required human labor, and a few were performed and required a man-machine power source. The level of mechanization in hp/ha computed for rice production and post-production in the province is 3.0942 (Table 7) when the reaping and threshing harvesting method is used.
On the other hand, the level of mechanization in hp/ha that is computed when the combining harvesting method is used is 3.7988 (Table 8). Tables 7 and 8 show the power consumption (hp) profile for rice that can be evaluated and indicate in the table that plowing, rototilling, and combined harvesting is the most energy-intensive operations, with 1.1015, 0.7038, and 1.0766 hp/ha,

respectively. It can be evaluated across all stages of agricultural production, from land preparation to the irrigation system's operation.

Table 7. Level of Mechanization, hp/ha (Reaping and Threshing Method)

Operation	Power Utilized (hp/ha)
Dike Repair	0.0216
Plowing	1.2507
Harrowing	0.7989
Rototilling	0.5865
Leveling	0.0398
Seedling Preparation	0.0064
Planting	0.0847
Cultivation and Weeding	0.0046
Fertilizer Application	0.0034
Pesticide Application	0.0024
Harvesting	
Reaping	0.0661
Threshing	0.3059
Hauling	0.1509
Drying	0.2189
Milling	0.2390
Irrigation	0.0316
Total	**3.0942**

Table 8. Level of Mechanization, hp/ha (Combining method)

Operation	Power Utilized (hp/ha)
Dike Repair	0.0216
Plowing	1.1015
Harrowing	0.1134
Rototilling	0.7038
Leveling	0.0398
Seedling Preparation	0.0064
Planting	0.0847
Cultivation and Weeding	0.0046
Fertilizer Application	0.0034
Pesticide Application	0.0024
Harvesting	
Combining	1.0766
Hauling	0.1509
Drying	0.2189
Milling	0.2390
Irrigation	0.0316
TOTAL	**3.7988**

4. CONCLUSIONS & RECOMMENDATIONS

This study assessed the level of mechanization in the rice production and post-production systems in Surigao Del Sur. In terms of demographic profiles, it was found that most of the farmers in the province are in their forties and above, and it is possible that in five to ten years, these farmers will not be as active and involved in various farming operations as they are right now. So, government, together with the private sector, must engage the youth in farming to fill in the gap caused by the potential retirement of farmers or farm laborers from agricultural activity.

In addition, the lack of formal education for rice farmers needs to be addressed, as this may cause problems, especially in adopting and managing new technologies.

Cost and return analysis showed that the net return of Php 24,878.78 per ha per cropping season would give a profit-cost ratio of 0.52. It also means that a rice farmer tilling one hectare would only get Php 6,219.70 monthly. High production cost, together with small farm sizes, consumes most of the returns of each rice farmer.

Despite government aid in the form of cash, inputs, and free machinery provided to each association, it has not been sufficient for them to achieve a satisfactory profit. To address this issue, the government should pay more attention to farmers today because they work so hard in their rice fields and receive so little in return.

The province's rising equipment usage for land preparation operations and mechanical harvesters is the most promising development in mechanization technology. Surigao del Sur's rice mechanization index is 3.7988 hp/ha and still significantly lower based on the index of level of mechanization.

The recommendation to improve the level of mechanization in the province of Surigao del Sur is the need for farmers to adopt technologies, especially in crop establishment, like mechanical transplanters or precision seeders. In addition, the government must equip the farmers by engaging them in immersive training for them to be knowledgeable in these kinds of technologies. Also, further study, particularly in designs of mechanical transplanters suited for the areas of the farmers.

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