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ARTICLE

Analyzing the Return-Benefit on the Use of Modern Agricultural Machinery by Rice Farmers in Nueva Ecija, Philippines Using Modern Portfolio Theory (MPT)

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ABSTRACT

The Philippines is among the leading rice consumers worldwide, and the agricultural industry provides employment for a substantial proportion of the rural populace. Nevertheless, rice production has other obstacles, such as a scarcity of cultivable land, fluctuations in climate, and inefficiencies in production methods. In order to tackle these concerns, the Philippine government and several agricultural organizations have been advocating for the adoption of agricultural mechanization. Hence, this study aims to assess the return benefits for rice farmers resulting from the adoption of modern agricultural machinery, employing the Modern Portfolio Theory (MPT) to analyze the risks associated with capital investment in mechanization. This study utilized a quantitative-descriptive research methodology using statistical tools such as frequency distribution, weighted mean, and Spearman Rho in analyzing the data gathered. The results showed that the adoption of modern agricultural machinery by rice farmers affected the return-benefit of their farming operations in terms of "Initial Cost", ranked as number one (Strongly Agree), while "Labor Savings" ranked least and was verbally interpreted as (Agree). The result shows that the main

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concern of the respondents is the cost integrated into repairs and maintenance. Rice farmers are advised to prioritize comprehensive training for modern machinery to improve the adoption of this technology.
Keywords: Modern Agricultural Machinery; Mechanization; Rice Farmers; Return-Benefit; Modern Portfolio Theory

1. Introduction

Agricultural mechanization incorporates the use of mechanical equipment, technology, and machinery for farming and crop production tasks. The development of these tools and techniques has significantly improved agricultural productivity, leading to innovations and the growth of modern industries. The use of mechanization in agriculture is vital for accelerating sector growth, as it prioritizes machinery over manual labor, thereby greatly improving efficiency and productivity. Farm machinery has not only augmented the mechanical advantage but has also played a crucial role in alleviating the drudgery associated with various agricultural tasks [1].

The recognition of the advantages of farm machines over manual labor among Philippine farmers signifies a significant shift in agricultural practices and mindset, despite the initial cost considerations and potential displacement of laborers [2]. Furthermore, governmental agricultural policies now prioritize achieving food self-sufficiency and security by adopting and utilizing technologies to enhance crop production and labor efficiency. The use of mechanical tools in the practice of rice farming has provided better-quality production output [3]. Some of these changes entail: from using carabaos to tractors, from manual planting to mechanical rice transplanters, and from manual harvesting to mechanical rice reapers and harvesters. Mechanized farming has therefore, on this aspect, brought down the cost of using the muscle work of farm laborers hence cutting the overall expenditure in the production of rice.

The rice-producing industry in the Philippines plays a vital role in ensuring the country's food security, as rice is a fundamental dietary staple for the majority of the people [3]. The Philippines is among the leading rice consumers worldwide, and the agricultural industry provides employment for a substantial proportion of the rural populace. Nevertheless, rice production faces other obstacles, such as a scarcity of cultivable land, fluctuations in climate, and inefficiencies in production methods.

Nueva Ecija, one of the leading provinces in the Philippines, topped the rank with 336 thousand hectares of rice area harvested [4]. Farming is still widely practiced in the province, being the top producer of rice in 2019. Although industrialization has significantly diminished farm areas, remaining rice farmlands are thriving to support rice consumption in the country. There is now an increasing awareness among Filipino farmers about the advantages of utilizing mechanization technologies in the agricultural production system. Farm owners reap substantial benefits from mechanized farming as it enhances the efficiency of rice cultivation while simultaneously reducing production costs. Improving smallholders' access to farm power and machinery inputs is crucial as machinery purchase is often beyond the means of a large proportion of the sector [5].

Mechanization is a critical component in increasing labor productivity in agriculture, emphasizing the potential for large-scale capital investments to revolutionize conventional farming methods [6]. The agricultural sector's ability to create capital is still constrained, though, as formal finance systems frequently divert funds from the industry. Insufficient funds are provided for the fixed and working capital requirements necessary for mechanization as a result of this financial mismatch. Insufficient funds make it difficult for farmers to purchase contemporary equipment and technology, which restricts their capacity to increase efficiency and output. The broad adoption of mechanization is hampered by this capital limitation, which is especially noticeable in developing nations where access to reasonable financing is limited. Realizing the full benefits of mechanization in agriculture therefore depends on removing these financial obstacles, which calls for focused policy interventions and creative financing strategies to guarantee that farmers can afford to invest in the equipment required to boost productivity and maintain agricultural growth.

Numerous studies have demonstrated that the return benefit model for contemporary agricultural machinery in rice cultivation demonstrates significant increases in both economic and production. Labor productivity and efficiency are greatly increased by mechanization, leading to reduced labor expenses and increased food yields[7]. For example, compared to conventional methods, mechanical transplanting and harvesting enhance planting density and decrease post-harvest losses, resulting in production gains of 10–20%. A thorough cost-benefit analysis conducted states that long-term labor savings and higher farm profitability more than make up for the initial large capital investment in equipment like tractors and combine harvesters[8]. The model also highlights the significance of financial accessibility, pointing out that low-interest loans and government subsidies can help small-scale farmers purchase machinery, increasing the economic advantages[9]. Moreover, case studies in Nueva Ecija provide empirical evidence that mechanized farms attain greater net incomes and operational efficiencies. This model emphasizes that mechanization is a very advantageous investment for the agricultural sector, even though the initial expenses are substantial due to the long-term production gains and financial rewards.

According to the aforementioned setting, it is empirically necessary to evaluate the agricultural machinery's return on investment using a method that will balance the risks and returns. Harry Markowitz developed Modern Portfolio Theory (MPT), which provides a solid framework for balancing risk and return in investment portfolio optimization. MPT may be applied to return benefit analysis in a variety of industries, including agriculture. Diversification should be used in an investment portfolio to optimize returns for a given amount of risk[10]. This approach, when applied to return benefit analysis, helps assess the possible advantages of investing in contemporary agricultural gear by taking into account both the related risks and the anticipated improvement in productivity and profitability[11]. For instance, purchasing contemporary equipment such as combine harvesters and tractors can greatly increase agricultural productivity and efficiency, resulting in larger profits. MPT is also a successful tool in other sectors. When MPT is implemented in the energy industry, financial assets are typically substituted with various energy technologies[12]. Also, MPT has been utilized in the financial industry to enhance regulations in investment management and to facilitate business diversification for risk management purposes[13].

These expenditures do, however, have some dangers, including high initial expenses, ongoing upkeep, and even technological obsolescence. Farmers and agricultural investors can improve the overall return-risk profile of their investments by using MPT to create an ideal investment portfolio that diversifies risks across various assets, such as machinery, crops, and farming techniques[8]. This tactical method guarantees that the incremental gains from further investments are optimized in comparison to their expenses, conforming to the concepts of effective resource distribution and risk mitigation.

So, with the issues determined by the researchers, this study aims to assess the return benefits for rice farmers resulting from the adoption of modern agricultural machinery, employing the Modern Portfolio Theory (MPT) to analyze the risks associated with capital investment in mechanization. This study will comprehensively analyze the return-benefit aspects of integrating modern agricultural machinery. Specifically, it sought to answer the following questions:

1. How may the business technical profile of the respondents be described in relation to their financial capacity to acquire modern agricultural machinery?
2. How does the adoption of modern agricultural machinery affect the return-benefit on farming operations of rice farmers specifically in terms of Initial Cost, Risk Aversion, Labor Savings, and Crop Productivity?
3. What is the relationship between the years of mechanization adoption and the financial returns as assessed using MPT?

From the mentioned context, the researchers managed to determine the structure of this study. Concerning the target population, the rice farmers, who will be the main focus of the study, will be assessed by the type of technical business profile they have in their rice farm-

ing businesses. The above technical profiles are important to establish since it will assist the researchers in discovering the extent of the relationship between the number of years of using modern agricultural machinery and the estimated annual net income evaluated in million dollars. Further, MPT will be employed to determine the return-benefit characteristic of farming operations and consequently identify the pros and cons involving the application of advanced equipment by the farmers. Lastly, the researchers should come up with a plan of action that will help the farmers to conduct a benefits analysis on the use of modern machinery.

2. Materials and Methods

This study utilized a descriptive research methodology with a quantitative approach, employing predesigned questionnaires to collect information. The aim was to assess the Return-Benefit of employing Modern Agricultural Machinery by rice farmers in Nueva Ecija, Philippines, using Modern Portfolio Theory (MPT) as a framework to establish a foundation for a Business Continuity Plan.

The adaptability of descriptive research, which includes a range of data gathering techniques such as surveys, observational studies, case studies, and focus groups [14], is essential for accurately reflecting the subtleties of farmers' experiences and the effects of contemporary agricultural gear.

The subject of this research was rice farmers of Nueva Ecija, Philippines, situated in the region, occupying the central section of . All districts of Nueva Ecija are places where researchers conducted the study, especially as the researchers intentionally sought help from some rice cooperatives such as Municipality Agriculture Laur, Gabay sa Bagong Pag-asa in Gapan, and Kasamne in Palayan City. By using purposive sampling in this manner, the researchers effectively accessed and engaged with rice farmers who have firsthand knowledge and experiences relevant to the research topic, facilitating a comprehensive analysis of return benefits and factors influencing machinery adoption within the framework of Modern Portfolio Theory. Based on the given list that the respondents received from the Cabanatuan City Agriculture Office, the total population in Nueva Ecija, Philippines is stated to be 134,000 people, specifically rice farmers. The researchers used the Raosoft sample calculator, which takes into account a 5% margin of error and a 95% confidence level. With a 50% response distribution, the total number of respondents calculated was 384.

The selection criterion prioritized farmers who possessed ample expertise in utilizing agricultural machinery. The following criteria were set to eliminate bias in the responses that may be extracted from the potential respondents: at least 3 years' experience in farming, with one or more agricultural machineries used for farming, and lastly, at least 2 consecutive years of earning from farming. This criterion guarantees that the participants possess a pragmatic comprehension of both conventional and contemporary farming methods, facilitating a more precise evaluation of the advantages and difficulties linked to modern gear.

The study seeks to collect trustworthy and strong data on the practical use and results of contemporary agricultural technology by focusing on experienced farmers. This method facilitates the assessment of the Return-Benefit ratio, as these farmers may provide comparison evaluations based on their vast usage experience. Moreover, their experiences can shed light on the pragmatic features of machinery utilization, such as upkeep, enhancements in productivity, and any possible disadvantages, thus facilitating a thorough comprehension essential for the application of Modern Portfolio Theory (MPT) to the agricultural industry.

The questionnaire and interview were used as the main data-gathering instruments. In the survey questionnaire, respondents were presented with two distinct sections of questions, each strategically designed to align with the study's goals and objectives.

Part I consists of questions that describe the business technical profile of the respondents, assessing the equipment used in farming, years of use of modern agriculture in farming, number of crop farming per year, estimated annual farming expenses in using machines, and estimated annual net income. This part of the questionnaire is a checklist modified and crafted by the researchers.

Part II consists of questions that assess the return-benefit in the adoption of modern agricultural machinery affecting the farming operations of rice farmers in terms of initial cost, risk aversion, labor savings, and crop productivity. This part of the instrument was formulated in the modified 4-point Likert scale, Strongly Agree (4); Agree (3); Disagree (2); Strongly Disagree (1).

The research instrument underwent validation, during which corrections and suggestions were integrated into the final draft. Subsequently, interviews were conducted with additional respondents to assess reliability, and experts were engaged to evaluate the instrument's validity.

The research study entitled "Analyzing the Return-Benefit on the Use of Modern Agricultural Machinery by Rice Farmers in Nueva Ecija, Philippines using Modern Portfolio Theory (MPT)" was conducted by asking for approval from the university and the permission of the farmers who are the respondents of the study. The researchers used survey questionnaires, Google Forms, and informal interviews as a research tools which serve as a medium to collect data. A semi-structured survey questionnaire was developed to gather quantitative data on various aspects of modern agricultural machinery adoption, return benefits, technical profiles of respondents, and other relevant variables. The questionnaire was designed based on the research objectives, literature review, and theoretical framework.

Moreover, the researchers conducted a dry run to check the reliability and validity of the formulated questionnaire. The reliability coefficient of the instrument was tested and measured to check the internal consistency, with the following consistency results: Initial Cost garnered 3.44, Risk Aversion has 3.25, Labor Savings has 3.14, and Crop Productivity was 3.3. The validity of the research instrument was established by presenting the developed instrument for the comments of the experts, who rated the instrument with a 3.92 general weighted mean and verbally interpreted it as a "Very good" questionnaire. The reliability coefficient of the instrument was tested and measured to identify the internal consistency. The validity of the research instrument was established by presenting the developed instrument for the experts' comments, who rated it.

The researchers also acknowledged the potential limitations in this study. One of the limitations is the research locale. The research was exclusively conducted in one of the many provinces in the Philippines, which signifies that the result does not represent other provinces. Another limitation is the use of an online survey. There are respondents who do not properly know how to use the instrument uploaded in online mode. Hence, the researchers performed follow-ups on their responses.

The data gathered from the respondents was encoded, tallied, and analyzed. Statistical tools such as percentage, frequency distribution, weighted mean, and Spearman Rho were used in analyzing the data gathered. Specifically, the researchers employed the following: frequency and percentage were used to describe the respondents' technical business profile to determine the actual business operations of the respondents; the researchers utilized the weighted mean to assess the adoption of modern agricultural machinery by rice farmers because of the potential similarities in the practice of the respondents; to identify the significant relationship between the years of use of modern agricultural machinery in farming and the estimated annual net income, the researchers employed Spearman Rho to determine which among the two variables holds a strength over the other.

3. Results

This chapter presents analyses and interprets all the data gathered in textual and tabular form.

3.1. Description of the Business Technical Profile of the Respondents

This section presents the business technical profile of the respondents described in terms of equipment used in farming, years of use of modern agricultural machinery in farming, number of crop farming per year, estimated annual farming expenses in using machines, and estimated annual net income.

3.1.1. Equipment Used in Farming

The majority of the respondents indicate that the reaper is the most commonly used equipment in farming, with a frequency of two hundred nine (209), or fifty-four

percent (54%) of the respondents, while other equipment as the lowest are only three (3), or one percent (1%) of the total respondents.

3.1.2. Years of Use of Modern Agricultural Machinery in Farming

Forty-two percent of respondents (161 farmers) reported using modern agricultural machinery for 3–4 years, while the lowest group, at twenty percent (77 respondents), reported 1–2 years of usage.

3.1.3. Number of Crop Farming per Year

Results show that the highest percentage of respondents' crop farming per year was twice a year with a frequency of two hundred sixty-four (264), or sixty-nine percent (69%), while the lowest respondents' crop farming per year was thrice a year, with a frequency of four (4), forming (1%) of the total respondents.

3.1.4. Estimated Annual Farming Expenses in Using Machines

Results show that the majority of the respondents' estimated annual farming expenses in using machines were 21,000–30,000, which is forty-seven percent (47%) with a frequency of one hundred eighty (180), while the lowest percentage was seven percent (7%) with a frequency of twenty-nine (29) and foresee costs exceeding 31,000.

3.1.5. Estimated Annual Net Income

Results show that the highest percentage of respondents estimated annual net income was seventy percent (70%), which falls within the 101,000 to 200,000 income range with a frequency of two hundred sixty-eight (268), while the lowest percentage, one percent (1%), reported incomes of 200,000 and above with a frequency of four (4).

3.2. Assessment of the Adoption of Modern Agricultural Machinery by Rice Farmers Affecting the Return-Benefit of their Farming Operation

3.2.1. Initial Cost

Table 1 shows the results of the adoption of modern agricultural machinery by rice farmers affecting the return-benefit of their farming operation in terms of initial cost. The majority of the respondents strongly sgree with the statement "Modern machinery is quite expensive to purchase immediately for many farms", having a weighted mean of 3.42. On the other hand, respondents only agree with "The high upfront cost creates a substantial obstacle for smallholder farmers adopting modern machinery", having a weighted mean of 3.23.

Table 1. Initial cost.

Initial Cost	Weighted Mean
1. Modern machinery is quite expensive to purchase immediately for many farms.	3.42
2. The initial expenses are affordable when considering the long-term benefits of using modern machinery.	
3. The initial cost barrier for farmers can be lowered by government support.	3.37
4. Modern machinery requires a significantly higher initial investment compared to traditional practices.	3.38
5. The high upfront cost creates a substantial obstacle for smallholder farmers adopting modern machinery.	3.23
Total	3.35

Note: Legend: 1.0–1.75 Strongly disagree, 1.76–2.50 Disagree, 2.51–3.25 Agree, 3.26–4.00 Strongly agree.

3.2.2. Risk Aversion

Table 2 shows the result of the adoption of modern agricultural machinery by rice farmers affecting the return-benefit of their farming operation in terms of risk aversion. It shows that the majority of the respondents strongly agree with the statement "The potential breakdowns and repairs involved in using advanced agricultural equipment make me hesitant to adopt them", with a weighted mean of 3.43. However, respondents only agree with the statement "To reduce the chance of operational disruptions and increase long-term production, risk-averse farmers are more likely to invest in high-end agricultural gear", with a weighted mean of 3.13.

3.2.3. Labor Savings

Table 3 shows the result of the adoption of modern agricultural machinery by rice farmers affecting the

Table 2. Risk aversion.

Risk Aversion	Weighted Mean
1. The potential breakdowns and repairs involved in using advanced agricultural equipment make me hesitant to adopt them.	3.43
2. Using modern machinery gives me greater control over my operations and reduces predictable risk.	3.22
3. To reduce the chance of operational disruptions and increase long-term production, risk-averse farmers are more likely to invest in high-end agricultural gear.	3.13
4. Risk aversion influences farmers' decisions when investing in machinery and equipment for their operations.	3.37
5. Risk-averse farmers typically prioritize investing in agricultural gear with warranties and safety mechanisms.	3.28
Total	3.29

Note: Legend: 1.0–1.75 Strongly disagree, 1.76–2.50 Disagree, 2.51–3.25 Agree, 3.26–4.00 Strongly agree.

return-benefit of their farming operation in terms of labor savings. The majority of the respondents strongly agree with the statement "The adoption of modern agricultural machinery has significantly reduced labor requirements in rice farming operations," garnering a weighted mean of 3.30. On the other hand, respondents only agree with "The adoption of modern agricultural machinery for labor-saving has positively influenced the return on investment of your rice farming operation," having a weighted mean of 3.16.

Table 3. Labor Savings.

Labor Savings	Weighted Mean
1. The utilization of modern agricultural machinery affected your overall labor costs in rice farming.	3.28
2. The adoption of modern agricultural machinery for labor-saving has positively influenced the return on investment of your rice farming operation.	3.16
3. The use of modern agricultural machinery for labor-saving purposes will continue to provide benefits to your rice farming operation in the long term.	3.23
4. The adoption of modern agricultural machinery has significantly reduced labor requirements in rice farming operations.	3.30
5. The adoption of modern agricultural machinery met your expectations regarding labor-saving benefits in rice farming.	3.28
Total	3.25

Note: Legend: 1.0–1.75 Strongly disagree, 1.76–2.50 Disagree, 2.51–3.25 Agree, 3.26–4.00 Strongly agree.

3.2.4. Crop Productivity

Table 4 shows the result of the adoption of modern agricultural machinery by rice farmers affecting the return-benefit of their farming operation in terms of crop productivity. It shows that the majority of the respondents strongly agree with the statement "Crop productivity significantly improves with the adoption of modern agricultural machinery," with a weighted mean of 3.38. However, respondents only agree with the statemnet "Improved crop productivity translates to higher income potential for rice farmers" with a weighted mean of 3.2.

3.3. Significant Relationship between the Years of Use of Modern Agricultural Machinery in Farming and the Estimated Annual Net Income

Table 5 shows the significant relationship between the years of use of modern agricultural machinery in farming and the estimated annual income of farmers. The correlation between the years of use of modern agricultural machinery and the estimated annual net income. The table shows that the Spearman Rho value of the years of use of modern agricultural machinery and estimated annual net income is 0.59344, ρ (2-tailed) = 0. Meaning, that by normal standards, the association between the two variables would be considered statisti-

Table 4. Crop productivity.

Crop Productivity	Weighted Mean
1. Improved crop productivity translates to higher income potential for rice farmers.	3.2
2. Crop productivity significantly improves with the adoption of modern agricultural machinery.	3.38
3. Improper use of machinery can lead to negative impacts on long-term productivity.	3.32
4. Sustainable practice and proper training on machinery use are crucial to ensure long-term productivity benefits.	3.29
5. Modern machinery has dramatically increased my overall crop productivity.	3.34
Total	3.31

Table 5. Significant relationship between the years of use of modern agricultural machinery in farming and the estimated annual income of farmers.

			Years of Use of Modern Agricultural Machinery in Farming	Estimated Annual Net Income
Spearman Rho	Years of use of modern agricultural machinery in farming	Correlation coefficient	1.000	0.59344
		sig. (2-tailed)		000
		N	384	384
	Estimated annual net income	Correlation coefficient	0.59344	1.000
		sig. (2-tailed)	000	
		N	384	384

cally significant. This signifies that rejecting the null hypothesis (H0: there is no significant relationship between the years of use of modern agricultural machinery and annual net income) is appropriate in this context.

4. Discussion

4.1. Description of the Business Technical Profile of the Respondents

In relation to the use of farming equipment, it was pointed out by the respondents that they mainly employed a reaper in their rice cultivation activities. The recognition of this machine is based on its great harvesting abilities, cost-effective labor and high production output. In fact, its usage marks a turn towards mechanization in agriculture since modern technologies like reapers have replaced conventional manual work done during rice paddy cultivation.

The economic practicality and operational advantages of using hand reapers in the collection of rice and wheat have been emphasized [14]. The analysis shows how expensive manual harvesting can be, with rice and wheat harvesting costs reduced by 58% and 53%, respectively, from manual practices. It points out the effectiveness of reapers especially on farming methods in which harvests are done mechanically. Moreover, Rahman's study underscores the importance of manual reapers for uneven fields where rice and wheat crops are cultivated. Manual reapers are skilled at navigating, and they have a lot of capability to remove plants under exceptional circumstances. This has made them an excellent alternative since they enhance efficiency by reducing labor requirements, especially among complex agricultural terrains. The valuable insights into the benefits and challenges associated with employing hand reapers in agricultural mechanization. These findings further disclose their potential to improve output, cut down production costs as well as enhance farming sustainability particularly when it comes to harvests on rice and wheat fields.

Still, there are different perspectives that point to some problems in this approach. Mechanical reapers may at times cause increased costs of operation and reliance on other firms for fixing broken parts and maintenance [15]. In such places, the operating costs of mechanical reapers may be higher than the savings in labor costs since there is limited access to technical services and spare parts. Consequently, smallholder farmers are left with no cash reserves. In addition, they argue that

the initial cost of modern mechanical reapers is substantially more than that of manual ones, thus complicating issues for smallholders.

Mechanization provides an adequate path for productivity advancement; that on the other hand, it may lead to socio-economic disruption. The replacement of traditional hand labor with mechanical reapers has been linked to the migration of agricultural workers, which can have wide-ranging effects on rural communities and increase urbanization trends. Developing agricultural societies to grow in a sustainable manner means moving the fulcrum between these socio-economic effects and productivity improvements.

People who have been using new agricultural machinery for an extended period were supposed to be more efficient as it required a level of expertise, which would help them adopt technological innovations in agriculture effectively. The fact that they still use modern tools and methods when appropriate demonstrates a successful integration of them into their traditional context as well as an ongoing commitment to the ethos behind these developments. The survey also provides insight into the ability of respondents to adopt new technologies in agriculture Farmers display their flexibility to the evolving agricultural climates, utility of new methodologies and knowledge of modern technologies by using advanced machinery for a longer duration consecutively. To remain competitive and profitable, it is important to be adaptive in the face of difficulties, whether that means labor shortages or environmental constraints [16]. In fact, the time frame in which modern agricultural machinery has been used shows that survey respondents invest money and willingness to participate in technological advances for bettering crop production cycle farming techniques. Commitments like this are essential if we expect to achieve long-term agricultural development, build resilience in the face of setbacks and contribute meaningfully to sustainable food production systems.

The findings provide evidence for semi-annual cropping by the respondents (two crop farming cycles per year). The practice is a common method being applied in a number of agricultural areas, such as the Philippines, to increase crop yield and improve product quality. Semiannual cropping allows farmers to diversify their crops during each cycle. Crop rotation is a trick that provides such hints as insect control, maintaining soil productivity, and reducing weather-dependent risks. The prominence of rice as the staple food in the Philippines, widely consumed by its population even unknowingly manifesting its essential role both for food security and nutritional requirements. The country grows rice on agricultural fields allowing for a double cropping system in irrigated areas, especially those with abundant water resources, like two harvests before the next drought starts. This skill not only ensures food availability, but also boosts agriculture for post-disaster challenges and increases production in a country which is an essential framework to secure food security as well as economic stability. It not only makes a significant contribution to the food production of the nation but also supports the livelihoods of thousands and thousands of rice farmers. Mechanization requires the use of an appropriate combine harvester for efficient rice production. This agricultural innovation is a must to enhance operational efficiency and help in getting the harvests done at the right time of optimum season, yielding the maximum crop possible. In addition, the application of integrated harvesters has a vital role in mitigating postharvest losses particularly among agricultural economies such as the Philippines, where food security and sustainability are paramount concerns [17].

When they calculate the annual expense of running machinery on the farm, farmers expect to pay anywhere from a little bit to high out-of-pocket dollars for storing their farming equipment. Such expenses usually include routine servicing, repair due to normal wear and tear, as well as intermittent enhancements or changes of some parts in order to maintain the functionality of machinery, equipment, and structure for price effectiveness. These figures show that farmers are doing their bit to financially plan in order to keep business operations both running and working. As a forward-looking statement on the asset maintenance and management front, it conveys that farmers are willing to spend dollars today for wear and tear in order to save millions of acres tomorrow.

Farmers expect a normal level of annual net income from their farming activities, as indicated in the pro-

jected yearly figures. This data shows the wide range in both revenue estimates and outcomes that exist among agricultural farmers. The statement underscores the broad range of operational scales, commercial opportunities and routes to profitability that farmers must navigate due to their own circumstances, resources, and business strategies. Unfortunately, the efficiency of policy and program interventions in general was hampered by the low rates at which technology is usually adopted within the global Nigerian agricultural sector. There is a discrepancy between the amount of effort put into creating strategies versus action-taking[18]. This has translated into low productivity and an average annual earnings of N 120,000 per farmer among rice farmers. The sharp contrast makes it clearer that interventions need to be specifically aimed at achieving a much higher technology penetration and improving economic returns for farmers.

Although the current agricultural technology is believed to have a high potential for improving productivity and efficiency, it must be applied with great care due to an array of challenges that come along. There is also need to determine the appropriate mix of mechanization and hallmark techniques or processes, together with their economic and socio-economic impacts among different farming conditions for a sustainable agricultural development.

4.2. Assessment of the Adoption of Modern Agricultural Machinery by Rice Farmers Affecting the Return-Benefit of Their Farming Operation

The initial cost of modern agricultural technology greatly affects the return on investment as it is quite high at first. Of course, the response in which most agree is "modern machinery is too expensive for immediate purchase by many farms," with a weighted mean of 3.42 They also concur that "the high upfront cost is a considerable entry barrier to smallholder farmers" (weighted mean of 3.23). The result shows that the very large first capital for machinery is a major disadvantage that cannot be afforded by all farmers especially small field farms or ones who do not have much money.

Farmers are reluctant to use agricultural machinery because of high acquisition and maintenance costs, as well as low annual profits[16]. Subsidies can stimulate machinery acquisition up front, then oversupply the market and drive down profitability so just when you get people to buy your overpriced machinery, they stop buying it. In addition, there is the important business of carrying out detailed risk assessments and planning mitigation strategies that spare us from depriving our children or grandchildren of technology because oversight has failed in delivering responsible implementation into practice[19]. He argues that it demands cautious treatment of the risks of modern technologies such as environmental effects and social disruptions.

However, some researchers emphasize that mechanization can lead to longer-term economic benefits. The high initial costs are a global deterrent but long-term financial profits can be achieved, as evidenced in labor savings and productivity improvements[19]. On the one hand, you have a long-term view where even though initial costs are high, so is arguably the return on investment over time. On the other hand, it is claimed that technological progress has contributed to higher durability in modern machinery, requiring less repair for upkeep relative to older machines so maintenance concerns can potentially be addressed through design[19].

These are things that farmers often mention as very difficult, with the reliability and maintenance costs of modern machinery being a significant factor in their adoption decisions. But the worry about turnaround time due to breakdowns and/or constant maintenance has understandably made them sheepish. The other side of the coin is that this caution often translates into a process-driven adoption cycle, especially if they determine significant risks or potential downsides such as downtime increases and spikes in maintenance costs. Finally, people should always think about what harm modern technology could do to both environmental and social inequalities before adoption[19]. Total risk assessments and mitigation strategies are mandated to ensure responsible, safe and sustainable technology deployment in agriculture.

Yet other studies showcase the advantages and disadvantages brought by the impact of modern machinery. Claiming improvements in agricultural technology

have resulted in greater results when modern machinery is compared to traditional models [13]. Newer machinery designs also include improved diagnostic tools and more resilient components; they determined that this should lead to fewer—but perhaps equally severe—breakdowns. This can reduce worries about the risk of operational delays and reduce ongoing maintenance costs.

Additionally, farmers need a system to adopt new technology that helps them in the long run [12]. Farmers will always have to weigh the risks and benefits before purchasing new machinery but by analyzing these more thoroughly sales personnel can plan ahead for incentives, better matching their options. Taking that care is also likely to result in more robust maintenance procedures and increased equipment life expectancy, driving down total costs.

Among rice farmers, the use of machinery has been favorable since it has been able to minimize the need for labor once used in farming and thus increase profitability in farming activities. The majority of the respondents strongly agree that the use of machinery has significantly reduced the number of people required in the process of rice farming, with a rating of 3.30. They also equally aver, but easily to the negative that such adoption has enhanced their return on investment with an average rating of 3.16. Concerning the implications of modern machinery, all the respondents observed that this aspect decreases employment demands resulting in the enhancement of output and proper resource management. Appropriate use of labor-saving technologies leads to improvements within the farmers' roles focusing on tasks including strategic planning, crop control and business development. Farm mechanization increases the rate and ease of various farming operations, hence improving production [20].

Nevertheless, there are apprehensions that the mechanization of processes will eliminate the need for manpower in countries that possess ample manpower and comparatively lower levels of development. Though mechanization is recognized for raising the labor productivity and income levels, it also leads to the displacement of hired labor in tasks involving physical effort like cultivation, reaping, threshing and milling. Operations that are today being performed with more facility by machinery.

As earlier stated, two diametrically opposed views are evident with regards to the effects of mechanization on employment and income distribution. Thus, although mechanization can increase efficiency, socio-economic transformations can occur as a result. They pointed out that when mechanized reapers replace conventional labor practices, then it leads to unemployment of the labor force hence affecting the livelihoods of rural people and increasing the rate of rural-urban migration. This social-economical factor must be appropriately weighed against the intended increase in productiveness for balanced community development in the agricultural sector.

In addition, some of the hassles that come with investment in modern machinery include the high price tag of the machinery and the constant need to cater to the maintenance costs, thus making it a burden in the long run for smallholder farmers . They learned that due to the difficulty of accessing technical services, spare parts and slow transportation in the rural space, mechanized reapers exert too much pressure on smallholder farmers in terms of costs of maintenance thus negating the effect of savings on labor.

The implication of the purchase and use of modern implements and machinery by rice farmers, therefore, affects yield outcomes and the efficiency of investment on their farms. Most of the respondents very much agree with the statement that "crop productivity enhances with the help of mechanization and new techniques" with the supported weighted mean of 3.38. They also concur, though not as strongly, with the statement "Increased crop yields increase income prospects of the rice growers," with a WMA of 3.2. The rice farmers realize that the advancements in modern agricultural technology, especially precision farming, proper resource utilization, timely processes, and improved crop techniques, all help in greatly improving both the yield and productivity of rice crops. High-tech implements and computer-aided technology help in planting, growth, and even in harvesting and storage. Strategies such as data analysis and forecasts form the foundation of improvements in practices by farmers.

The integration of digital technologies and agricultural mechanization has changed the farming practices in several ways by controlling losses and increasing operating efficiency which is fruitful for farmers [21]. These technologies stand as important implements that should be promoted for the purpose of increasing yields and generally improving the standard of living of the farmers.

Nevertheless, there are some works that describe opposite opinions about the effects of modern agricultural machinery on crop yields. Mechanization is helpful from the point of view of productivity increase, but at the same time, it can result in the application of heavy machinery and the lack of retention of traditional knowledge and farming techniques needed for efficient and sustainable agriculture [22]. Some of the negative effects popularized by high mechanization include soil deterioration and crop diversification, a problem that poses a severe danger to the long-term sustainability of food production.

Furthermore, it is also important to understand that mechanization does not hold the same advantages in all localities and farming types. Even in developed countries where machinery is produced locally, based on the current development where some regions have yet to embrace advanced technological advancements, the level of productivity that is expected to be achieved by the use of modern machinery may not be realized. This study discovered that in certain circumstances, machinery failure and repair expenses can outweigh the enhanced productivity of the machinery and place great pressure on the farmers' financial status as well as the rate of profitability of their farms, which could be negatively affected.

4.3. Significant Relationship between the Years of Use of Modern Agricultural Machinery in Farming and the Estimated Annual Net Income

The correlation coefficient that was obtained provides some evidence that farmers estimated annual net income is a function of their use of modern agricultural machinery duration. This denotes that the use of Ministry recommended and advanced equipment in agriculture is beneficial to farmers in the aspect of income earning either through revenue multiplier effect, solving the challenge of labor intensity or through more efficient use of inputs in farming activities. RCH adopted improved farmers' income compared to hand harvesting methods by slashing the costs of labor, an important expense in agricultural production [23]. This results in large profits for the farmers.

As for the impact of property rights, it was revealed that landowners tend to have greater net income because of omitting fixed land rentals, which are production costs. Also, increased amounts of agricultural production led to an increase in revenue since revenue = price × quantity, with a constant price. The use of advanced agricultural practices such as mechanization pushed the yields up, hence improving the revenue of farmers. In this context, the study stresses the need for the reincarnation of agricultural professionalism towards revenues in the booming area of rice production. Age, as a proxy for experience, shows that farmers who conduct rice farming with more years of experience achieve better results in terms of net returns due to the enhanced skills that come with mastery of experience. These are the aspects of technological advancement in farming, the proportion of land owned by farmers, yield management and farming experience which in one way or another affect the financial profit of farmers in rice farming.

However, there are some other works that give opposite opinions concerning the impact of mechanization on the magnitude of profits in the long run. The capital costs of modern machinery, both for purchase and maintenance, are sometimes more than the benefits accruing from their use in the production process, chiefly for smallholder farmers [24]. In areas where access to technical assistance and spare parts is still a challenge, the cost is high, which puts pressure on the machinery's maintenance by offsetting the net income gains expected.

However, although mechanization helps increase production rates, it also causes social and economic disturbances. They noted that with mechanized reapers taking over the work that was previously done by hand, many farm laborers are left unemployed, leading to social problems like the augmentation of rural people's

movement to urban areas. This socio-economic effect needs to be addressed alongside the increase in productivity so that communal agricultural livelihoods can be sustainably developed.

However, mechanization created positive financial changes with the exception of mechanization in farming [25]. The savings from buying modern machinery may not necessarily lead to an even greater increase in net earnings because the transport costs and marketplace problems in areas of low development may hinder and swallow up all the gains made through mechanization.

5. Conclusions

Based on the findings, the researchers were able to draw the following conclusions:

The majority of respondents, having utilized reapers for 3–4 years in their twice-yearly crop farming, allocated an estimated annual budget of 21,000–30,000 for expenses in using machines while generating an annual net income ranging from 101,000–200,000.

In terms of the Initial Cost, the majority of the respondents strongly agree with "Modern machinery is quite expensive to purchase immediately for many farms"; in terms of Risk Aversion, the majority of the respondents strongly agree with "The potential breakdowns and repairs involved in using advanced agricultural equipment make me hesitant to adopt them"; in terms of Labor Savings, the majority of the respondents strongly agree with "The adoption of modern agricultural machinery has significantly reduced labor requirements in rice farming operations"; in terms of Crop Productivity, the majority of the respondents strongly agree with "Crop productivity significantly improves with the adoption of modern agricultural machinery."

There is a significant relationship between the years of use of modern agricultural machinery in farming and the estimated annual income. This indicates a rejection of the null hypothesis.

Based on the findings, the researchers were able to provide the following recommendations:

The farmers are advised to prioritize comprehensive training for modern machinery, adopt crop rotation practices to improve yields, thoroughly evaluate machinery quality to minimize costs, and develop strategic budget plans to achieve optimal profitability.

It is recommended that the government should provide demonstrations and training sessions that highlight the labor-saving benefits of modern machinery and the direct link between productivity and income, which are crucial not only for the farmers but also for other labor-related industries. Tailored interventions addressing these concerns can significantly encourage the adoption of modern machinery in rice farming, thereby improving the return on investment.

Given the significant relationship between the years of using modern agricultural machinery and estimated annual net income, it is recommended that both experienced and new users engage in continuous skills development through tailored training programs. Access to ongoing technical support, participation in collaborative learning networks, and opportunities for knowledge exchange among different labor-related workers exchange within the agricultural community are also crucial.

For future researchers, it is recommended to recognize the importance of using this existing study as a foundation for new scientific results particularly a deeper understanding of the Modern Portfolio Theory. This study on the Modern Portfolio Theory can be a basis for applying other related theories to discover new results and knowledge.

6. Patents

No patents resulting from the work reported in this manuscript.

Author Contributions

The following are the contributions made by the researchers in the development of this research paper. Conceptualization, F.D.J. and B.J.P.; methodology, M.R.M.; validation, C.F. and F.D.J.; formal analysis, F.D.J., S.S.P., and B.J.P.; investigation, C.F.; resources, all the 5 authors; data curation, F.D.J., S.S.P., B.J.P.; writing, F.D.J.; writing—review & editing, visualization, all the 5 authors; supervision, project administration, F.D.J.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Nueva Ecija University of Science and Technology and approved by the Institutional Review Board Nueva Ecija University of Science and Technology.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the respondents to publish this paper.

Data Availability Statement

Data is unavailable due to privacy or ethical restrictions as disclosed to the respondents.

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Conflicts of Interest

The authors declare no conflict of interest.

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