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FACTORS AFFECTING THE ADOPTION OF COMBINE HARVESTERS AMONG RICE FARMERS IN BALIWAG, BULACAN, 2016

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ABSTRACT

The promotion of mechanization in rice production is essential in increasing the competitiveness of the rice industry of the Philippines. One aspect of rice mechanization is the use of combine harvesters, which is claimed to reduce harvesting cost and shorten harvesting time. However, the adoption of combine harvesters in the country is still low and little is known about the factors which affect the decision-making process of farmers towards the adoption of combine harvesters. Hence, this study was conducted to determine the factors affecting the adoption of combine harvesters among rice farmers in Baliwag, Bulacan.

A total of 40 combine harvester adopters and 40 non-adopters was interviewed. Adopters were classified as those who used combine harvesters for at least one season in 2016. The harvesting methods used by the farmers were through the use of combine, reaper and manual labor.

The harvesting costs and harvesting time of combine harvesting were found out to be significantly lower than for both the reaper and manual methods. Using partial budget analysis, it was shown that shifting from reaper to combine harvesters increased net farm income by 17.76 percent and 26.73 percent during the dry and wet season, respectively. Compared to the manual method, adopting combine harvesters increased net income by 21.36 percent during the dry season and 28.62 percent during the wet season.

The most popular reasons for adopting combine harvesters were reduced costs and shorter harvesting time, which farmers also found to be very advantageous before the arrival of typhoons. On the other hand, the non-adoption of combine harvesters was due to the farmers' consideration of displacing their regular manpower during harvesting which, in turn, deprived these laborers of their means of livelihood. While the non-adopters were aware of the economic benefits from combine harvesting, they put so much weight on the welfare of the laborers. These were actually validated in the logistic regression analysis. Adoption of combine harvesters was likewise associated to the famer's perception of the skills of the laborers. The more skilled the laborers, the less likely the farmer would resort to combine harvesting.

Due to the benefits of adopting combine harvesters, it is imperative that the use of this machine be promoted. One way to do this is by conducting seminars which teach farmers on the economic benefits of combine harvesting. On-farm trials can also be conducted by the government and private individuals/corporations so that farmers can get a hands-on experience with this machine. However, as shown from the results of the study, simply focusing on the economic benefits of combine harvesting is not enough. Its employment effects must also be considered. Thus, it is essential that the promotion of combine harvesters be also supplemented by the development of various industries that could absorb the displaced laborers arising from combine harvester adoption.

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[1]Thesis manuscript submitted in partial fulfillment of the requirements for graduation with the degree of Bachelor of Science in Agricultural Economics, Major in Farm Management and Production Economics from the Department of Agricultural and Applied Economics, College of Economics and Management, University of the Philippines Los Baños. Prepared under the supervision of Dr. Salvador P. Catelo.

BOYD LUIS ANTONIO CAPITO TOLENTINO

INTRODUCTION

Background of the Study

For decades, self-sufficiency in food staples, particularly rice, has been the policy of various administrations of the Philippine government. Various programs have been initiated by the government with the goal of increasing the productivity and profitability of rice production in the country. One of these programs is promoting the mechanization of rice production.

In rice farming, mechanization increases the productivity and efficiency of labor through improving the timeliness of farm operations. It also “increases cropping intensity, reduces labor requirement and production costs, and improves the competitiveness of a country relative to other global market players” (Bordey, Moya, Beltran, & Dawe, 2016).

Because of this, mechanization is important in the attainment of food security (Banta, 2016) and food self-sufficiency (Amongo, Amongo, & Larona, 2011).

In the Philippines, rice mechanization is promoted by the Agri-Pinoy Rice Program, which is under the Food Staples Sufficiency Program (FSSP). The laws that guide mechanization are the Agriculture and Fisheries Modernization Acts (AFMA) of 1997 and Agricultural and Fisheries Mechanization Law (AFMech) of 2013. These laws were created to modernize Philippine agriculture through the implementation of different technologies such as mechanization. These acts have five main goals: poverty alleviation and social equity, food security, global competitiveness, sustainable development, and income profitability (Banta, 2016).

In rice production, mechanization is typically done in different rice farming operations such as land preparation, planting, harvesting, and threshing. In harvesting, the most popular machine used is the combine harvester. The machine is called as such because it does the three farming operations – reaping, threshing, and winnowing – in one process. Its use has seen an increase in the efficiency and profitability of harvesting among rice farmers (Moya & Casiwan, 2006). Santos (2015), for instance, reported that the usage of combine harvesters incurred fewer costs and had a faster harvesting time compared to manual harvesting for farmers under the Agri-Pinoy Rice Program in Licab, Nueva Ecija. Llorente (2016) and Bordey et al. (2016) found similar findings in Alcala, Pangasinan and Nueva Ecija, respectively.

However, the use of combine harvesters is opposed by rice farm laborers. They call the machine *"halimaw"* or beast, citing it as the reason for the loss of their jobs during the harvest season (Roque, 2014). The displacement onf the laborers was supported by a study by Macasadia (2015) which showed that the use combine harvesters decreased the agricultural employment of farm workers in San Ildefonso, Bulacan.

Statement of the Problem

Although it has been shown that combine harvesters decrease the cost and increases the efficiency of harvesting, there is still a low adoption of combine harvesters among rice farmers in the Philippines (Banta, 2016). Based on the data from PhilRice's Rice-Based Household Survey from 2011-2012, the percentage of rice farmers in the Philippines who used combine harvesters in their largest parcel was only 0.33 percent during the wet season, and 0.68 percent during the dry season. In Nueva Ecija, the biggest rice-producing province in the country, the adoption of combine harvesters among rice farmers was only 3 percent in 2013. Most farmers still practice manual harvesting, which is more labor-intensive, more costly, and less efficient than combine harvesting (Bordey et al., 2016; Llorente, 2016; Santos, 2015).

This is also one of the reasons why the competitiveness of the rice industry in the Philippines is not up to par with other countries, as reported in a study conducted by the Philippine Rice Research Institute (PhilRice), in cooperation with the International Rice Research Institute (IRRI) in 2013 (Bordey et al., 2016). The study compared the competitiveness of the Philippine rice industry with several rice-producing countries in

Asia. Each country was represented by a region that had a significant impact on the rice production of that particular country and had similar characteristics with each other. In the Philippines, the region represented was the province of Nueva Ecija. The study showed that the low usage of machinery, particularly in planting and harvesting, resulted in an increase in the cost of labor and, thus, increased the production cost of rice. The increase in the cost of labor was the reason why the price of rice in Nueva Ecija was relatively higher than the similar regions in rice exporting countries such as Thailand and Vietnam. Because of this, it may be inferred that the competitiveness of the rice industry of the Philippines is lower than these countries. The study also reported that these countries had a high usage of farm machinery, specifically combine harvesters.

However, combine harvester adoption Nueva Ecija has significantly increased in recent years, According to the Office of the Provincial Agriculturist of Nueva Ecija, about 70 percent of rice farmers in the province now practice combine harvesting. However, nearby provinces have not yet widely adopted this machinery. One such province is Bulacan, where, according to the provincial agriculturist office, only several towns have high adoption rates of up to 80 percent. In the rest of the municipalities, combine harvesting, although used, is still not widely adopted.

In addition, despite the fact that there is already information about the increase in the adoption rates of combine harvesters in some provinces of the country, and the still low adoption rates in some areas of the country, very little information is available regarding their causes. In general, there is a lack of studies regarding the adoption of farm machinery in the country. Although there are some studies done about the factors affecting the adoption of agricultural technologies (Aranas, 2009; Mariano, Villano, & Fleming, 2012), there is little in regard to mechanization, particularly on rice combine harvesters.

Significance of the Study

Increasing the adoption of rice mechanization will help towards the attainment of the policy of the Philippine government towards rice self-sufficiency. It also helps enhance the competitiveness of the rice industry by decreasing the cost of labor and thus reduce the price of rice. Because of the decreased cost in rice, it also helps in the attainment of food-security because it makes rice more affordable. One aspect of mechanization in rice farming is combine harvesting. Thus, it is appropriate that a study regarding the factors affecting the adoption of combine harvesters must be done.

The results gained from this study may contain relevant information that could be used to identify and address the problems that constrain farmers from adopting combine harvesters. This may be helpful for the modification of existing policies and programs or create new ones that can help increase adoption more efficiently.

One of these programs could be the provision of subsidies on machinery. According to Bordey et al. (2016), subsidy on machinery, not input subsidy, is the only realistic subsidy that would have a substantial impact on lowering the costs of production. They further stated that subsidies on combine harvesters would be the best option to make rice farms in the Philippines more competitive.

Aside from helping the government, the knowledge gained from this study could also help the private sector be aware of the opportunity to invest in combine harvester production and hiring services. The results of the study could also assist them to determine which factors are relevant to the adoption of combine harvesters, and thus, may help combine harvester operators to market their service to rice farmers effectively. Similarly, farmers' associations and cooperatives may use this knowledge in assisting their members in adopting combine harvesters in order to increase the profitability and efficiency of their farming operations.

If the endeavors on increasing the use of combine harvesters and farm mechanization are successful, it might result in an increase in the youth engagement in farming. In a study done by Manalo and van de Fliert (2013) about the youth's out-migration from agricultural communities in Aurora, because farmers struggle to survive to meet the needs of their households. Hence, they discourage their children to take up farming and make them focus on their education in the hope that they will receive better and more profitable employment outcomes. Finding methods to make farming more lucrative might inspire farmers to encourage their children to take up farming. Because combine harvesting, makes farming more efficient and more profitable, the widespread use of combine harvesters may make farmers and the youth to see farming as a feasible source of livelihood. Farmers may also encourage their children to farm. This is important because Filipino farmers get older by the years without any replacements who would take on their task since there is a declining engagement of the youth in agriculture (Banta, 2016).

Objectives of the Study

The main objective of the study was to determine the factors that affect the adoption of combine harvesters and the net-benefits of combine and non-combine harvesting practices among rice farmers in Baliwag, Bulacan.

The specific objectives of this study were:

1. to describe the decision-making process of farmers towards the adoption of combine harvesters;
2. to determine the benefits and costs of combine and non-combine harvesting;
3. to identify the problems that constrain rice farmers from the adoption of combine harvesters; and
4. to provide solutions and recommendations that could increase the adoption of combine harvesters.

REVIEW OF RELATED LITERATURE

Competitiveness of the Philippine Rice Industry

In 2013, a study was conducted by PhilRice in collaboration with IRRI to assess the competitiveness of Philippine rice production in comparison to other Asian countries. The results of the study were compiled by Bordey et al. (2016) in a book entitled "Competitiveness of Philippine Rice in Asia." The study assessed the cost of rice production in selected intensively cultivated regions in six countries which have similar characteristics: the Philippines (Nueva Ecija), China (Zhejiang), Indonesia (West Java), India (Tamil Nadu), Thailand (Suphan Buri), and Vietnam (Can Tho).

Among the six countries, it was found out that the Philippines (Nueva Ecija) had the third highest rice production cost per kilogram (Figure 1). The Philippines, at PhP 12.34 per kg, was nearly twice as to that of Vietnam (Can Tho) which was at PhP 6.50 per kg, the lowest cost among the selected regions.

One reason for this difference is the difference in land productivity. The high productivity of land in Can Tho resulted in a higher rice yield -a significant factor in lowering the unit cost of rice. Nueva Ecija only has two harvest seasons a year while Can Tho has three. Average yields in Nueva Ecija were 5.68 metric tons per hectare (mt/ ha) and 3.84 mt/ ha (wet season). Can Tho, on the other hand, had 6.33 mt/ha during summer-autumn; 5.55 mt/ ha in autumn-winter; and 8.78 mt/ ha during winter-spring.

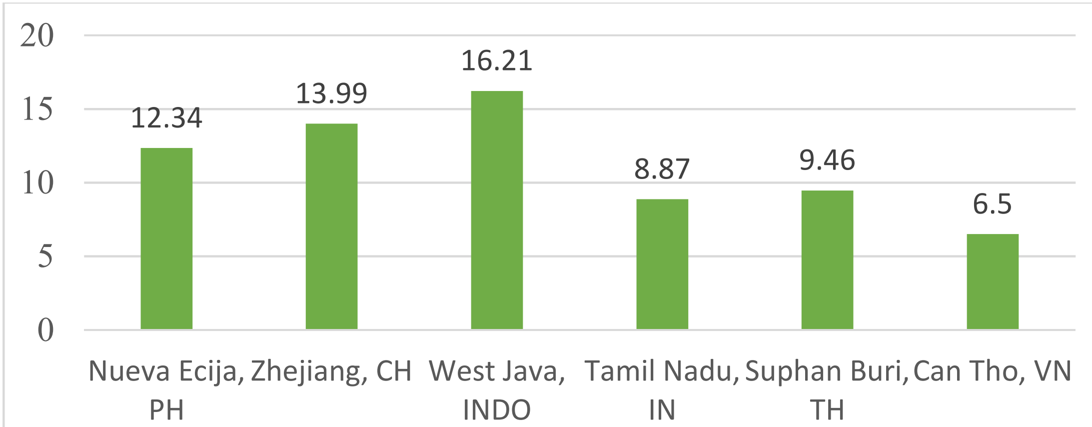

Figure 1. Production cost of rice (PhP) per kilogram of selected intensively cultivated rice producing regions in Asia, 2013.
Source: Competitiveness of Philippine Rice in Asia (Bordey et al., 2016)

The difference in land productivity is also consistent with the report of Moya & Casiwan (2006). They indicated that that major rice exporting countries, such as Thailand, Vietnam, and Cambodia, are all in mainland Southeast- Asia – a region that is blessed with river deltas and wide lands which are suitable for rice production. Traditional rice importers such as the Philippines, Indonesia, and Malaysia, however, consist of islands and narrow peninsulas.

Another factor that contributed to the high cost of rice production in Nueva Ecija was the labor cost. The labor cost amounted to PhP 3.76 per kilogram of paddy in Nueva Ecija. This was tremendously higher than in Can Tho, where farmers only paid P0.46 per kg. The difference was primarily attributed to the practice of direct seeding and the usage of combine harvesters in Can Tho. On the other hand, labor-intensive practices such as transplanting and manual harvesting were still popular in Nueva Ecija. Also, fuel and machine rent in Nueva Ecija (PhP 1.73/ kg of paddy), cost more than twice than in Can

Tho (P0.80/ kg). One explanation for this was the higher efficiency of machines in the latter than in the former.

However, farmers in Nueva Ecija had a higher profit (P4.8/ kg) than those in Can Tho (P3.09/ kg). The average price for the two provinces was P17.21/ kg and P9.59/ kg, respectively. Marketing rice in Nueva Ecija was more costly than in Can Tho. The gross marketing margin (GMM), which includes the costs of drying, milling, transport, storage, and the profit margins of middlemen, is estimated to be at P5.08/ kg in Nueva Ecija, almost twice that of in Can Tho with only P2.87/kg.

Based on the findings of the study, it could be concluded that rice production in Vietnam is more productive and less costly. The higher production and marketing costs of rice and the restriction and high tariffs on imports cause the retail price of rice in the country to be greater than that of Vietnam. This is a great detriment to the Philippine population since rice is a staple food. However, lowering the tariff on rice and relying on imports to reduce its price in favor of the consumers will make rice farmers in the country suffer. Moreover, solely relying on importation is impossible because the global rice surplus is less than what the country needs. Also, continuously relying on protective measures will only decrease the competitiveness of the Philippine rice industry rather than improve it (Bordey et al., 2016).

For the Philippines to be competitive, “farmers and processors must be able to produce rice with the same or superior quality at costs than those of international competitors” (Bordey et al., 2016). One of the ways to do this is by lowering the labor cost of rice, the second biggest factor which affects the cost of rice production. The main cause of the high labor cost in the Philippines is the lack of mechanization. Hence, mechanization should be promoted aggressively. One aspect of mechanization is harvesting, specifically the use and adoption of combine harvesters – which this study is about.

Rice Mechanization in the Philippines and in Asia

In 2013, a study conducted by the Philippine Center for Postharvest Development and Mechanization or PhilMech (as cited in Banta, 2016), showed that rice mechanization in the country was still at a relatively low level. Negligible levels of mechanization in some regions of the country were found in planting, weeding, spraying, and harvesting. Regarding farm area, the most mechanized farming operations were plowing (37.68%), harrowing (39.96%), and threshing (49.68%). Harvesting, on the other hand, is only at 2.16 percent. This implies that mechanization of rice harvesting in the Philippines is not that widespread. Interestingly, the study found that Region III, the rice granary of the Philippines, only had 0.54 percent of its land area mechanized while Regions I and II both had 9.18 percent, higher than the national average. The study also showed that the sum of human, animal, and mechanical inputs was only at 2.31 hp/ ha.

This information is also supported by the PhilRice study in Nueva Ecija (Bordey et al., 2016). It was reported that land preparation and threshing, which involved the use of two-wheel tractors and axial threshers, were the only operations highly mechanized. Only a tiny percentage of farmers used combine harvesters. The study also inferred that the low level of mechanization in the country might be attributed to the abundance of farm labor in various regions of the country.

There was also a greater ownership of low-cost farm mechanization equipment than high-cost machinery. These expensive machines were typically owned by private traders and processors, as well farmer's associations and cooperatives through grants and soft loans granted to them by the government. Moreover, less than half of Nueva Ecija farmers own farm machinery. However, this was also the same for other countries because they rely on the rental market to ensure the wide scale use of machinery.

Bordey et al. (2016) also reported that compared to other Asian countries, the Philippines is still far behind in terms of mechanization. The two types of machinery that were widely used in the country were the axial thresher and the two-wheel tractor. In comparison, the widely used machines in India, China, Thailand, and Vietnam, which are rice exporting countries, are four-wheel tractors and combine harvesters. The majority of the farmers in these countries adopted four-wheel tractors in comparison to the Philippines 0 percent. There was nearly a hundred percent adoption rate for combine harvesters in these four countries, a stark contrast to the Philippines 3 percent.

Combine Harvesting in the Philippines

Profitability and Efficiency

According to Bordey et al. (2016), the most popular method of rice harvesting in the Philippines is still manual harvesting; which is especially true in Nueva Ecija. Threshing, however, is highly mechanized using an axial flow thresher. The two operations both need a total of 21 man- days per hectare. On the other hand, a combine harvester can do both of these operations in just two man-days. While manual harvesting and axial-flow threshers combined cost 17 percent of the harvest in total, combine harvester only costs 8 percent. The difference is equivalent to P1.56 per kilogram of paddy.

Other studies also reported similar findings Santos (2015) indicated that combine harvesting is more profitable and has a faster harvesting time than manual harvesting for farmers under the Agri-Pinoy Rice Program in Licab, Nueva Ecija. Llorente (2016) found that combine harvesting reduced postharvest losses and lowered harvesting cost in Alcala, Pangasinan. These findings were also supported by the results of similar studies in other countries (Chi, 2008; Poungchompu & Chantanop, 2016).

It could be concluded that combine harvester not only reduces labor cost but also makes harvesting faster and more efficient. Combine harvesting also solves the problem of the seasonal labor shortage that occurs during harvesting. However, it is still a major concern for farm laborers because this type of harvesting may displace them from work.

Adoption

The adoption of combine harvesters among rice farmers in the country is still relatively low. Based on the data from PhilRice's Rice-Based Household Survey from 2011-2012, the percentage of rice farmers in the Philippines who used combine harvesters in their largest parcel was only 0.33 percent during the wet season, and 0.68 percent during the dry season. For all parcels, combine harvester adoption remains at a low percentage, varying among the different provinces. As seen in Figure 2, the top 3 provinces which had the highest proportion of adopters (16.8%-27.9%) were Ilocos Norte, Pampanga, and Bohol. Other provinces which also had the highest adoption rates were Pangasinan, Tarlac, Laguna, Agusan del Norte, Zamboanga del Sur, Davao del Norte and North Cotabato. The results of the survey were also identical to the study of Bordey et al. (2016) in 2013 which reported that only 3 percent of rice farmers in the Philippines adopted rice combine harvesters.

Agricultural Technology Adoption

Adoption of agricultural technologies is seen as an important way to combat poverty in many developing countries (Mwangi & Kariuki, 2015). It has also been associated with increased earnings, improved nutrition, lower staple food prices, and increased employment (Kasirye, 2010). Because of this, technical change is the cornerstone of most agricultural policy, programs, and projects (Loevinsohn, Sumberg, Diagne, & Whitfield, 2013). Therefore, it is important to study the factors which can increase the adoption of these technologies among farmers.

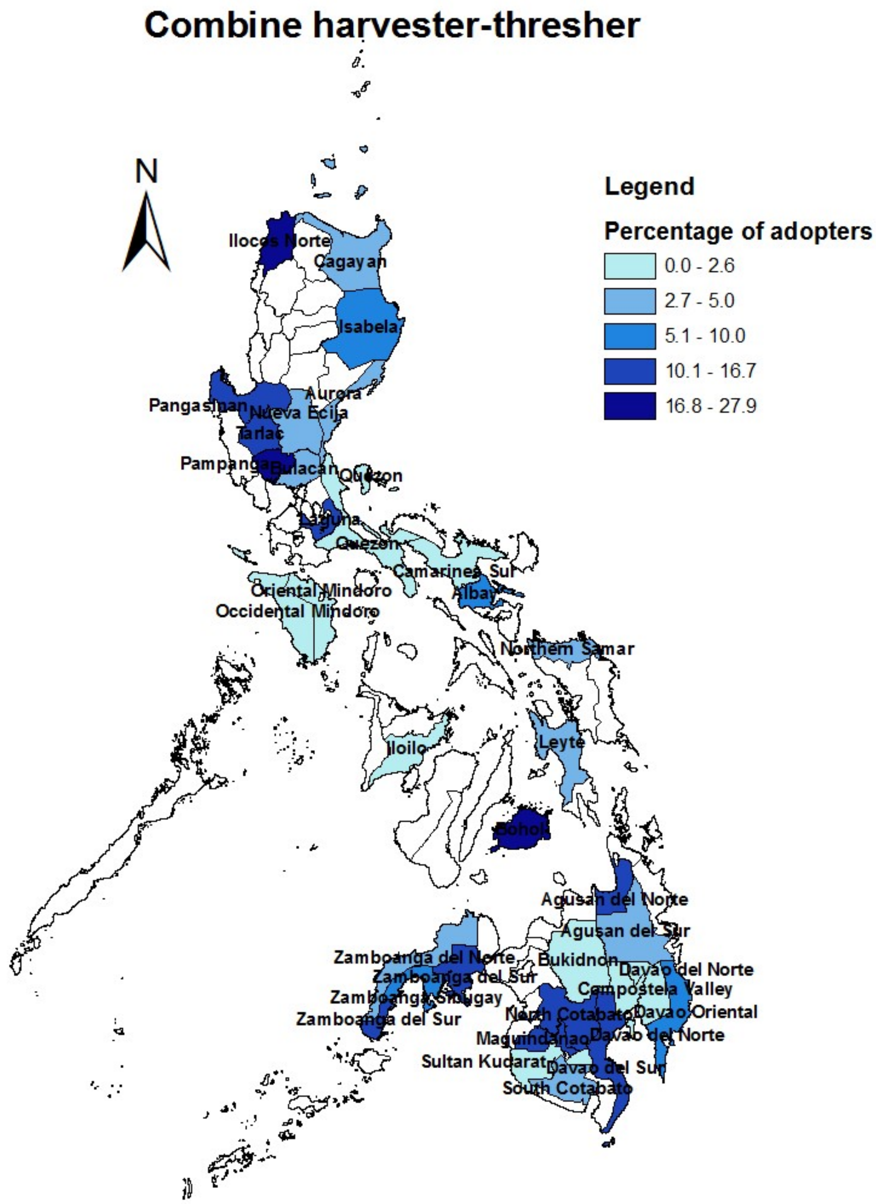

Figure 2. Percentage of rice farmers adopting combine harvester-thresher for all parcels of land in the Philippines.
Source: PhilRice Rice-Based Household Survey 2011-2012

Defining technology adoption, however, is a complicated task since it could vary with the technology being adopted. The first thing it could depend upon is whether adoption is defined as discrete or continuous (Doss, 2006). Defining adoption as discrete means that adoption is classified into two categories, whether the farmer adopts the technology or not. This is commonly measured through the use of binary logit models. Adoption could also be defined as continuous. This is commonly used when finding the extent of adoption of technologies. Probit models are commonly used in this definition. Logit and probit analysis are typically employed in studies determining the factors affecting technology adoption because they provide more detailed information on the characteristics of farmers who would adopt a specific technology (Mariano et al., 2012).

Because of the vast amount of research in agricultural technology adoption, different factors affecting the adoption of technology have been studied – with varying results. In the study of Mwangi and Kariuki (2015), these factors were classified by into four different categories: technological, household specific, economic, and institutional, factors. Technological factors refer to the characteristics of the technology. Household-specific factors refer to age, gender, education, and household size. Economic factors include farm size, net gain of adoption, and off-farm income. Institutional factors include the farmer's belonging to a social group, their acquisition of information, access to extension services, and access to credit.

Technological factors

The characteristics of a technology are important factors because these are the preconditions for farmers if they will adopt it (Mwangi & Kariuki, 2015). The study of Mignouna, Manyong, Rusike, Mutabazi, and Senkondo (2011) stated that technological characteristics are essential in the adoption decision process; farmers would more likely adopt the technology if they perceive it to be consistent with their needs and is compatible with their environment. These characteristics are also important in determining the benefits that the farmers expect from the technology. A study by Akudugu, Guo, & Dadzie, (2012) included farmers' expected benefits as a factor that influences the adoption of agricultural production technologies. Their study showed that if the anticipated advantages of the farmer in adopting a new technology were higher than the benefits of their current practices, they would most likely adopt it.

Household- specific Factors

Age of is one factor that is commonly included in the studies of agricultural technology adoption. Different studies have shown that having a higher age negatively affects adoption (Ayodele, 2012; Howley, O. Donoghue, & Heanue, 2012). Ghosh (2010) stated that younger generations are more likely open to farm mechanization. Older farmers have more experience in farming -accumulated through experimentation and observations. Because of this, they may find it difficult to abandon their traditional practices for new technologies. On the other hand, Akudugu et al. (2012), in their study of the adoption of modern agricultural production technologies in Ghana, found out that age assumed a quadratic function. This means that the rate of adoption of technologies is low at both the younger and older ages. They reported that this might imply that younger farmers do not have adequate resources to invest in technologies, especially those that are capital intensive.

Education is another factor that has been known to influence technology adoption. Some studies have shown that education has a positive effect on adoption (Chi, 2008; Uaiene, Arndt, & Masters, 2009). The reason for this is that education affects the attitudes and thoughts of the respondents which make them more open and rational. This eases the introduction of an innovation and lets them analyze the benefits of new technology (Adebiyi & Okunlola, 2013).

Another factor that is widely studied but has varying evidence is gender. Mignouna et al. (2011) stated that gender affects the adoption of agricultural technology since men, who are commonly the primary decision makers, have more access and control over production resources than women. This is consistent with the studies done by Mlenga & Maseko (2015), and Uaiene et al. (2009) On the other hand, Morris and Doss (1999) found no significant association between gender and probability to adopt improved maize in Ghana. They concluded that decisions regarding technology adoption primarily depend on the accessibility of resources, not on gender.

Household size is used as a measure of labor availability (Mwangi & Kariuki, 2015). It may be inferred that an increase in household size increases labor availability. This may negatively affect the decision of farmers to adopt technologies because there may be less of a need to adopt technologies, which is commonly used as a substitute for labor. This relation is consistent with the studies of Mlenga and Maseko (2015) and Mariano et al. (2012).

Economic Factors

Farm size is also another factor that affects agricultural technology adoption. In the study of Ghosh (2010) in the Burdwan Districts of West Bengal, the author found out that farm size is a significant factor in the adoption of agricultural mechanization. He reported that having a larger farm size positively influences adoption. Other studies have shown similar results (Akudugu et al., 2012; Mariano et al., 2012). Farmers who operate on larger farms are more likely to adopt new technologies since they can afford to devote a part of their land to try and test its effectiveness (Uaiene et al., 2009). Also, certain technologies like mechanized equipment and animal traction, require economies of size to be profitable (Feder, Just, & Zilberman, 1985).

The cost associated with a particular technology is also seen as a factor that influences its adoption. Having high costs is considered to be a hindrance to the adoption of some technologies (Mwangi & Kariuki, 2015). A study done by Makokha, Kimani, Mwangi, Verkuijl, and Musembi (2001) on finding the factors affecting the use of fertilizer and manure in maize production in Kiambu county, Kenya reported that high labor and input costs, unavailability of packages demanded, and untimely delivery as the primary hindrances to the adoption of fertilizers. The cost of hired labor was also seen as a constraint in the study of Ouma et al. (2002).

Off- farm income has also been shown to have a positive impact on technology adoption. Off- farm income provides farmers with liquid capital for purchasing inputs, such as improved seed and fertilizers. It also acts as a substitute for borrowed capital, especially in places where there are missing or dysfunctional credit markets (Diiro, 2009; Ellis & Freeman, 2004) Because of this, off-farm income can enhance the adoption of technologies, in particular for the ones which have high costs.

Institutional Factors

Extension is seen to have a positive effect on the adoption of agricultural technologies. Access to extension services is essential in promoting modern agricultural production technologies because it can counteract the negative effect of low levels of formal education in the decision-making process of farmers (Yaron, Voet, & Dinar, 1992; as cited by Mwangi & Kariuki, 2015). Extension officers also provide inputs and technical advice to farmers (Mlenga & Maseko, 2015). A study by Akudugu et al. (2012) about the adoption of modern agricultural production technologies by farm households in Ghana confirmed that extension access was a significant factor in influencing the adoption of technologies.

Farmer's access to credit is seen to influence in technology adoption. Simtowe & Zeller (2006) stated that access to credit "promotes the adoption of risky technologies through relaxation of the liquidity constraint as well as through the boosting of households risk bearing ability." Access to credit has been found to have a significant positive impact on the adoption of agricultural production technologies in Ghana (Akudugu et al., 2012).

Another factor that may influence the adoption of agricultural technologies is the acquisition of information about these technologies. It promotes the technology's existence to farmers and its effective uses, thereby facilitating its adoption. Access to information through extension services reduces the uncertainty about a technology's performance which may change the farmer's assessment from purely subjective to objective over time (Caswell, Fuglie, Ingram, Jans, & Kascak, 2001). However, access to information may also negatively affect adoption. If the experience with a particular technology is limited, having more information discourages farmers towards adopting it because more information makes farmers more aware of additional aspects of the technology which may bring more uncertainties, increasing the risk associated with it (Bonabana- Wabbi, 2002).

The membership of a farmer in social groups, such as associations and cooperatives, is another factor that has been studied in recent years. Social groups are important for decision making because farmers share information and learn from each other's experiences (Uaiene et al., 2009). Social groups may also have a negative effect on adoption. Bandiera and Rasul (2006) reported that because farmers are risk-averse, they might delay adopting a technology to "free-ride" on the information gathered by other farmers in their social group. These farmers only adopt the technology when they find out its effectiveness from other farmers first. Thus, the authors reported that the relationship between the two variables follows an inverted U- shaped individual adoption curve. The effect of social groups on adoption increases at a particular point, but because of the effect of free-riding, the effect decreases and eventually becomes negative.

Studies Related to Combine Harvesters

Poungchompu and Chantanop (2016) reported in their study on the economic aspects of rice combine harvesting services for farmers in Northeast Thailand that the significant factors that affected adoption of combine harvesters were farmers' education, farm size, and family size. Higher education and farm size both positively affected adoption while an increase in family size negatively affected it.

Hassena, Ensermu, Mwangi, and Hugo (1995) reported that the significant factors in combine harvester adoption are accessibility, education, and farm size. This was based on their study entitled "A Comparative Assessment of Combine Harvesting Vis-à-vis Conventional Harvesting and Threshing in Arsi Region, Ethiopia." Accessibility of the farmers was measured in terms of a farmer's nearness to towns and topography of the area. It was then categorized as accessible and non-accessible. Adoption of combine harvesters increased when they were near combine hiring stations and had a terrain that is favorable for combine harvesting. Education, which was measured as two variables: primary and secondary, and farm size, also positively affected adoption.

Santos (2015) studied the effects combine harvesting on the output and income of rice farmers under the Agri- Pinoy Rice Program in Licab, Nueva Ecija. She found out that most farmers adopted combine harvesters because it decreases the time for harvesting operation. Fifty-four (54) out of a hundred (100) farmers said that this was so. Another reason for their adoption was that combine harvesters eased harvesting, especially during the wet season.

On the other hand, the loss of income among their hired laborers was the primary reason for the non-adoption of combine harvesters for a high majority of farmers (74%). Because of this, they still preferred manual harvesting to prevent the displacement of their laborers. Other reasons include high acquisition cost, high fuel prices, and the lack of knowledge about the machine.

CONCEPTUAL FRAMEWORK

The factors associated with the adoption of combine harvesters among rice farmers in Baliwag, Bulacan is presented in Figure 3. These factors are grouped into four categories: socioeconomic, institutional, perception and attitudes, and physical/technical factors. All of these factors are based on studies that were presented in the literature review.

Socioeconomic factors include age, education, household size, non-rice income, and farm size. Age may negatively affect adoption because older farmers tend to be less willing to adopt new technologies. Education is also important in increasing the adoption of combine harvesters; farmers who obtained a higher educational attainment can have a better grasp and analysis of the technology. Household size negatively affects adoption; a higher size means that more labor is available. This leads to a decrease in the willingness to adopt labor-saving technologies because ample labor is available. An increase in the non-rice income of the farmer will increase the capital available for him or her invest using combine harvesting, positively affecting his decision to adopt it. It also decreases the risk of investing since the farmer has more sources of income if such a venture will fail. Farm size also positively affects adoption since having a bigger farm means that there is more area to harvest, which is not only time-consuming but also more expensive and laborious to harvest manually.

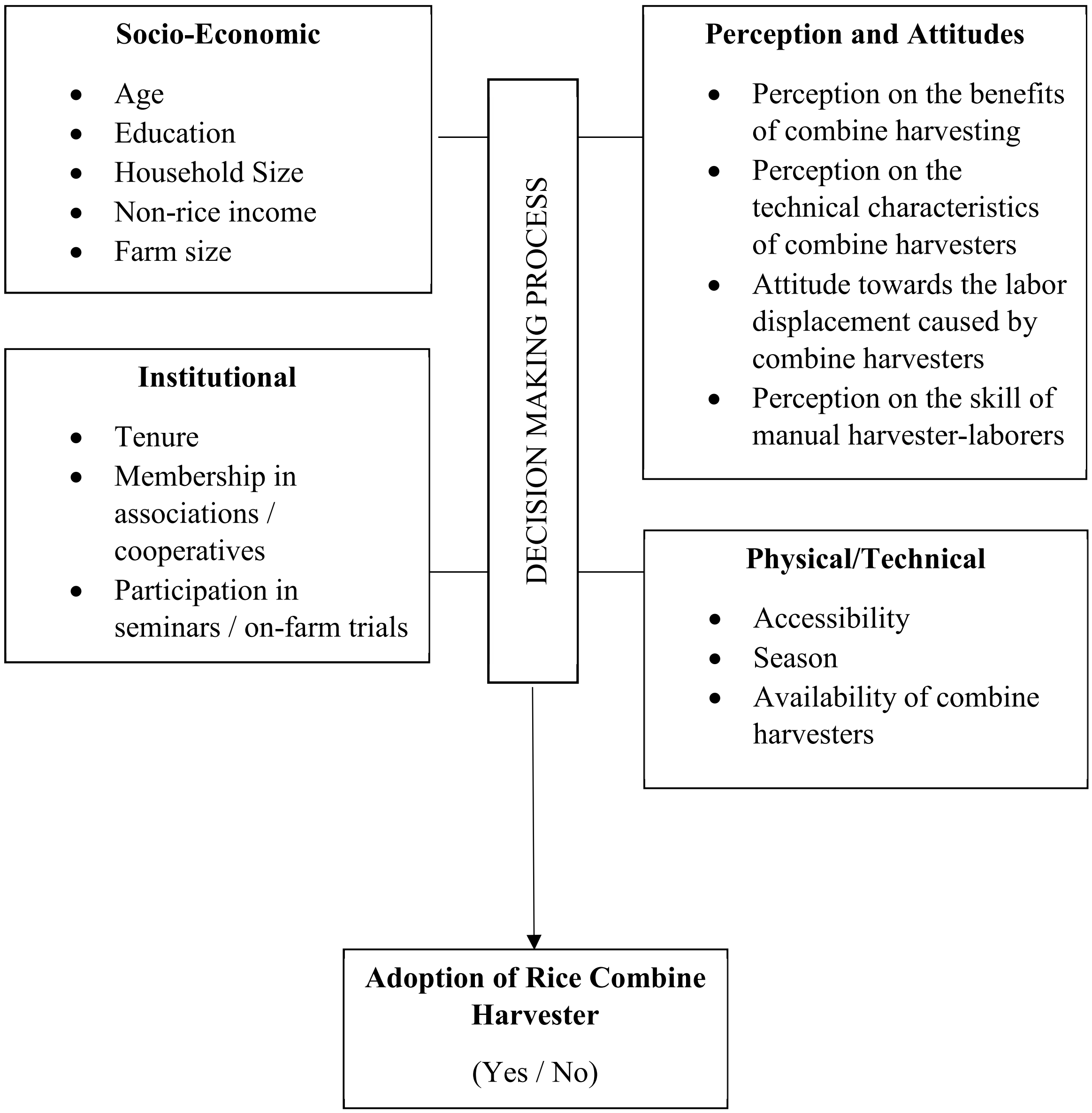

Figure 3. Conceptual framework of the factors that affect the adoption of combine harvesters among farmers in Baliwag, Bulacan

The institutional factors are tenure, membership in associations or cooperatives, and participation in combine harvester seminars or on-farm trials. Although tenure is not significant in some studies, it is also included since farm ownership may reduce the risk for the farmer in adopting combine harvesters. Membership in associations or cooperatives may also increase the farmers' willingness to adopt. Members may influence others through the word-of-mouth by exchanging positive information regarding these machines. Participation in seminars and on-farm trials can increase adoption because these will give them more information about the benefits of combine harvesting, thus leading them to try out the combine harvesting.

The perception and attitudes of the farmer towards benefits, characteristics, the labor displacement effects of combine harvesting and the skill of manual harvesters may also have a role in affecting their decision to adopt combine harvesters. If a farmer perceives combine harvesting to be more beneficial, he or she would be more willing to adopt it. The same effect is true if a farmer perceives the technological characteristics of combine harvesting to be better than manual harvesting. The attitude of the farmer towards the labor displacement caused by combine harvesting may also have a significant effect towards adoption. If the farmer is more likely to be against displacing their farm laborers in favor of combine harvesting, the farmer would be less willing to adopt the latter. If farmer perceives manual harvester-laborers to be skilled in their work, the farmer would also be less willing to adopt combine harvesters.

The Physical and Technical factors include the farm's accessibility to combine harvesting services, season, and the availability of combine harvesters in the area of the farmer. If the farm is accessible to combine harvester services, it may affect the farmer's willingness to adopt the machinery. Season also affects adoption since manual harvesting during the wet season is tedious and the usage of combine harvesters may ease the harvesting process. Availability of combine harvesters or the number of combine harvesters in the area increases adoption. A higher number of combine harvesters in the area will mean that combine harvesting services can be more easily accessed and thus be more practical than hiring combine harvester services based in other areas.

The four categories of factors affect the decision-making process of farmers towards adoption. This will then lead to whether they would adopt or not adopt combine harvesting.

HYPOTHESES OF THE STUDY

Based on the objectives of the study and the review of related literature, the following hypotheses were formulated:

1. Socio-demographic, institutional, perception and attitudes, and physical/technical factors affect the adoption decision of farmers towards combine harvesters.
    a. Education, knowledge about combine harvesters, non-rice income, farm size, net rice income, credit access, tenure, membership in associations or cooperatives, participation in seminars or on-farm trials, farm accessibility to combine harvesting services, and season (wet season), increased availability of combine harvesters (number of combine harvesters), and a positive perception of the benefits of combine harvesting positively affect adoption.
    b. Age, household size, having a negative attitude towards the labor displacement caused by combine harvesters, negative perception of the technical characteristics of combine harvesting, and having a positive perception of the skill of manual harvester-laborers negatively affect adoption.
2. Combine harvesting was more profitable than manual harvesting.

RESEARCH METHODOLOGY

Selection of the Study Area

The province of Bulacan was selected as the area of the study. The province was chosen because combine and non-combine harvesting were practiced in that province. However, the study was limited to the municipality of Baliwag due to financial and time constraints. Moreover, this municipality was selected because it has a relatively good number of rice farmers who practice combine and non-combine harvesting.

Selection of the Respondents

. The respondents of the study were selected using simple random sampling. The respondents were taken from the list of rice farmers provided by the Municipal Agriculturist Office. The sample size was computed using the following formula:

$$n = \frac{Z^2_{\alpha/2}(0.25N)}{N\varepsilon^2 + 0.25Z^2_{\alpha/2}} \text{ where } Z^2_{\alpha/2} = \begin{cases} 2.575, \text{if } \alpha = 0.01 \\ 1.96, \text{if } \alpha = 0.05 \\ 1.645, \text{if } \alpha = 0.10 \end{cases}$$

where:

n = sample size

α = significance level

N = total population of rice farmers

ε = tolerable error

Z = Z-score

A confidence level of 90 percent with a confidence interval of 12.75 percent was used. In the formula, this was represented by having a significance level (α) of 0.10 with a tolerable error (ε) of 0.1275. From a total population size (N) of 1,810, it was computed that the respondents in the study to be composed of 80 rice farmers: 40 combine harvester adopters and 40 non-adopters. Adopters are classified in this study as farmers who used combine harvesters in at least one harvesting season in 2016.

Type of Data and Method of Data Collection

Primary data during the wet and dry harvest season of 2016 was used in the study. The data were gathered through a survey of randomly chosen rice farmers using a pre-tested questionnaire which included information such as socioeconomic characteristics; harvesting method; cost and returns; attendance to combine harvester seminars/on-farm trials; and questions regarding their perception, attitudes, and problems encountered regarding their decision making process towards the adoption of combine harvesters.

Analytical Procedure

Descriptive Analysis

Descriptive analysis was used to describe the socioeconomic characteristics of the farmer; their knowledge about combine harvesters; decision-making process towards combine harvester adoption; and problems and constraints they encountered towards the adoption of the machinery.

Costs and Returns Analysis

This analysis was used to determine the benefits and costs of combine and non-combine harvesting. Primarily, this was used to determine the differences in the costs of combine and non-combine harvesting. Cost and return items for rice production were also computed to determine the effect of the harvesting methods on the net farm income of the farmers. The variables that were used in this analysis are the total farm revenue (TR), total farm cost (TC) and net farm income (NFI), which was the difference between the two former variables and plus/minus any gain/loss on the sale of capital assets (Aragon et al., 2010). This was given by the formula:

$$NFI = TR - TC$$

where:

NFI = net farm income (in PhP)

TR = total revenue (in PhP)

TC = total cost (in PhP)

The revenue from rice production was categorized into cash and non-cash revenues. Cash revenue was from the sale of rice (in cash) while non-cash revenue came from the home consumption of rice.

Costs were classified as cash and non-cash costs. Cash costs included expenses on inputs, machine rental, and labor. Non-cash costs include expenses such as depreciation of fixed assets (buildings, tools, and equipment), and the shares of production of the landlord, thresher, and harvester.

Partial Budget Analysis

In order to determine the net-benefits of adopting combine harvesting from non-combine harvesting methods, partial budget analysis was used. This was done comparing the gains and losses in adopting combine harvesting. The format for this analysis is given in the table below (Table 1).

Table 1. Partial budget analysis format

ADDED RETURNS	ADDED COSTS
Total Added Returns (I)	Total Added Costs (III)
REDUCED COSTS	REDUCED RETURNS
Total Reduced Costs (II)	Total Reduced Returns (IV)
SUBTOTAL (A = I + II)	SUBTOTAL (B = III + IV)
NET GAIN (A-B)	

Attitudes and Perception Analysis

Attitudes and Perception analysis was used for the determination of the farmer respondents attitudes and perception towards combine harvesters. Primarily, this was used to determine farmer's knowledge about combine harvesters, a factor which is hypothesized to affect the decision-making process of farmers towards the adoption of this machinery.

The attitudes and the perceptions of the farmer respondents were measured through the use of a Yes or No test composed of questions about their perception of the benefits and technical characteristics of combine harvesters, characteristics of combine harvested palay, and attitude towards labor displacement caused by combine harvesters. The questions asked are shown in Appendix Table 1.

Logistic Regression Analysis

To determine which factors hypothesized were significant in affecting the decision-making process of farmers towards the adoption of combine harvesters, a binary choice model was used. These models are used when economic decision makers choose between two mutually exclusive outcomes (Hill, Griffiths, & Lim, 2008). In this study, the farmer's choice of harvesting method is represented by the dummy variable:

$$z = \begin{cases} 1 & \text{farmer adopts combine harvesting} \\ 0 & \text{farmer practices manual harvesting} \end{cases}$$

The probability that a farmer adopts combine harvesting can be represented by the following equation:

$$P[z = 1] = \mathrm{P}_i$$

From this equation, it follows that the probability that the farmer practices manual harvesting can be represented by:

$$P[z = 0] = 1 - \mathrm{P}_i$$

The specific binary choice model that used was the logistic regression analysis or the logit model. This model is based on the cumulative logistic probability (Gujarati, 2003, as cited by Villarosa, 2014). In this model, the probability P_i that the farmer adopts combine harvesting is specified as:

$$P_i = P(z) = f\left(\beta_0 + \sum_{i=1}^{N} \beta_i X_i\right) = \frac{1}{1 + e^{-z}}$$

$$P_i = \frac{1}{1 + e^{-\left(\beta_0 + \sum_{i=1}^{N} \beta_i X_i\right)}}$$

Where:

P_i = probability of adopting combine harvester

z = measure of the total contribution of all the independent variables used in the model

β_0 = constant

N = number of independent variables

β_i = coefficients of the independent variables

X_i = independent variables (factors that affect combine harvesting adoption)

e = base of the natural logarithm

This equation can also be expressed as:

$$P_i = \frac{e^{(Z_i)}}{1 + e^{(Z_i)}}$$

$$Z_i = \beta_0 + \sum_{i=1}^{N} \beta_i X_i$$

Both sides are then multiplied by $1 + e^{(Z_i)}$,

$$P_i + e^{(Z_i)} P_i \ = \ e^{(Z_i)},$$

The factor $e^{(Z_i)} P_i$ is then transposed and distribution is performed,

$$P_i \ = \ e^{(Z_i)} + e^{(Z_i)} P_i = \ (1 - P_i) e^{(Z_i)}$$

Which equates to,

$$\frac{P_i}{1 - P_i} = e^{(Z_i)}$$

The natural logarithm of both sides is then taken,

$$\ln \frac{P_i}{1 - P_i} = \ Z_i$$

The dependent variable in the formula is represented by the logarithm of the probability that a particular decision was made. Because P_i represents the probability of combine harvester adoption and $1 - P_i$ represents the probability of using manual harvesting, the ratio $\frac{P_i}{1-P_i}$, also known as the odds ratio will determine whether the farmer would adopt combine harvesting. If P_i is equal to zero, then $\frac{P_i}{1-P_i}$ would also be equal to zero.

The regression probability is:

$$\ln\frac{P_i}{1-P_i} = z = b_0 + b_1X_1 + b_2X_2 + \cdots + b_nX_n$$

Therefore, variable *z* was defined in this study as:

$$z = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \varepsilon$$

Where:

z = adoption of combine harvester (1 = using combine harvester, 0 = not using combine harvester)

X_1 = farmer's age (in years)

X_2 = farmer's education (in years)

X_3 = farmer's household size

X_4 = non-rice income (in PhP/ cropping season)

X_5 = farm size (in hectares)

X_6 = land tenure (1 = owned/partly owned, 0 = wholly rented)

X_7 = membership on cooperatives/associations (1 = yes, 0 = no)

X_8 = participation in combine harvester seminars or on-farm trials (1 = yes, 0 = no)

X_9 = Perception on the benefits of combine harvesting (total number of questions with yes-responses)

X_{10} = Perception towards the technical characteristics of combine harvesting (total number of questions with yes-responses)

X_{11} = Attitude towards the labor displacement caused by combine harvesters (total number of questions with yes-responses)

X_{12} = Perception on the skill manual harvester-laborers (1 = positive perception on their skill level the last time they hired them, 0 = otherwise)

ε = disturbance term

Originally, two factors from the conceptual framework were included in the model. These were the farm's accessibility to combine harvesters and the availability of combine harvesters. The model did not include accessibility because almost all farms in the study were considered accessible to combine harvesters. However, it should be noted that a couple of farms did not adopt combines because their farm was inaccessible (Table 23). Availability, which was measured as the number of combine harvesters per barangay, was also not included because it was difficult to measure. According to the Municipal Agriculture office of Baliwag, there were around ten combine harvesters who are servicing the entire municipality. However, it can be considered that for all of the respondents, combine harvesting services are available. This was because all of them have been approached by combine harvester servicers directly and indirectly.

For variables X_{11} and X_{12}, and an increase each of their values means a more negative perception of the farmer towards the benefits and technical characteristics of combine harvesters respectively. Likewise, an increase in X_{13} means a more negative attitude towards the labor displacement caused by combine harvesters. This means that farmers are more opposed to the use of combine harvesters because it displaces laborers from their work.

LIMITATIONS OF THE STUDY

Because of time and financial constraints, the study was limited to only 80 respondents and to one municipality. Because of the relatively low number of respondents in comparison to the population size (1,810), the factors ascertained in the study may not correspond to the actual factors that determine the adoption of all combine harvesters. Moreover, since the study used limited cross-section data, results may differ in other periods and places. It should be noted that combine harvesters have only been introduced in the municipality in the last 2-3 years

However, this does not diminish the significance of the study. The adoption model, rather be interpreted as definitive, can serve as a reference for further researches. The results may find an utmost use for adoption studies of combine harvesters and other cost-saving technologies that should be aggressively promoted towards competitiveness and sustainability of the rice industry.

RESULTS AND DISCUSSION

Description of the Study Area

The municipality of Baliwag is located in the northwestern part of Bulacan. It is bounded on the northwest by Pampanga, on the south by Pulilan, on the southeast by Plaridel and Bustos, and on the northeast by San Rafael (Figure 4). It is classified as a first class urban municipality with a population of 149,954. It has a total land area of 4,491.06 hectares, in which 3,131.71 is devoted to agriculture. It is composed of 27 barangays, of which 18 are agricultural. These 18 barangays are Calantipay, Tarcan, Catulinan, Pinagbarilan, Makinabang, Matangtubig, Tangos, Sta Barbara, Tilapayong, Sabang, Piel, Sullivan, Barangca, Hinukay, Paitan, San Roque, Pagala, and Sto Nino. Like other municipalities in the western part of Bulacan, Baliwag's topography is generally flat, with most of its land area classified as lowland.

The main livelihoods of the townspeople are industrial employment and farming. Numerous textile factories and industrial facilities can be found in the town, most of which are located in the urban areas. Rice fields are situated all over the outskirts of the town's urban centers, occupying about 65 percent of the towns total land area (2,903.32 ha). Other crops grown in the town include, among others, watermelon (128.33 ha), mungbeans (46.69 ha). Other top agricultural use of land includes mango (5.10 ha), livestock and poultry (26.33 ha) and fishponds (7.845 ha).

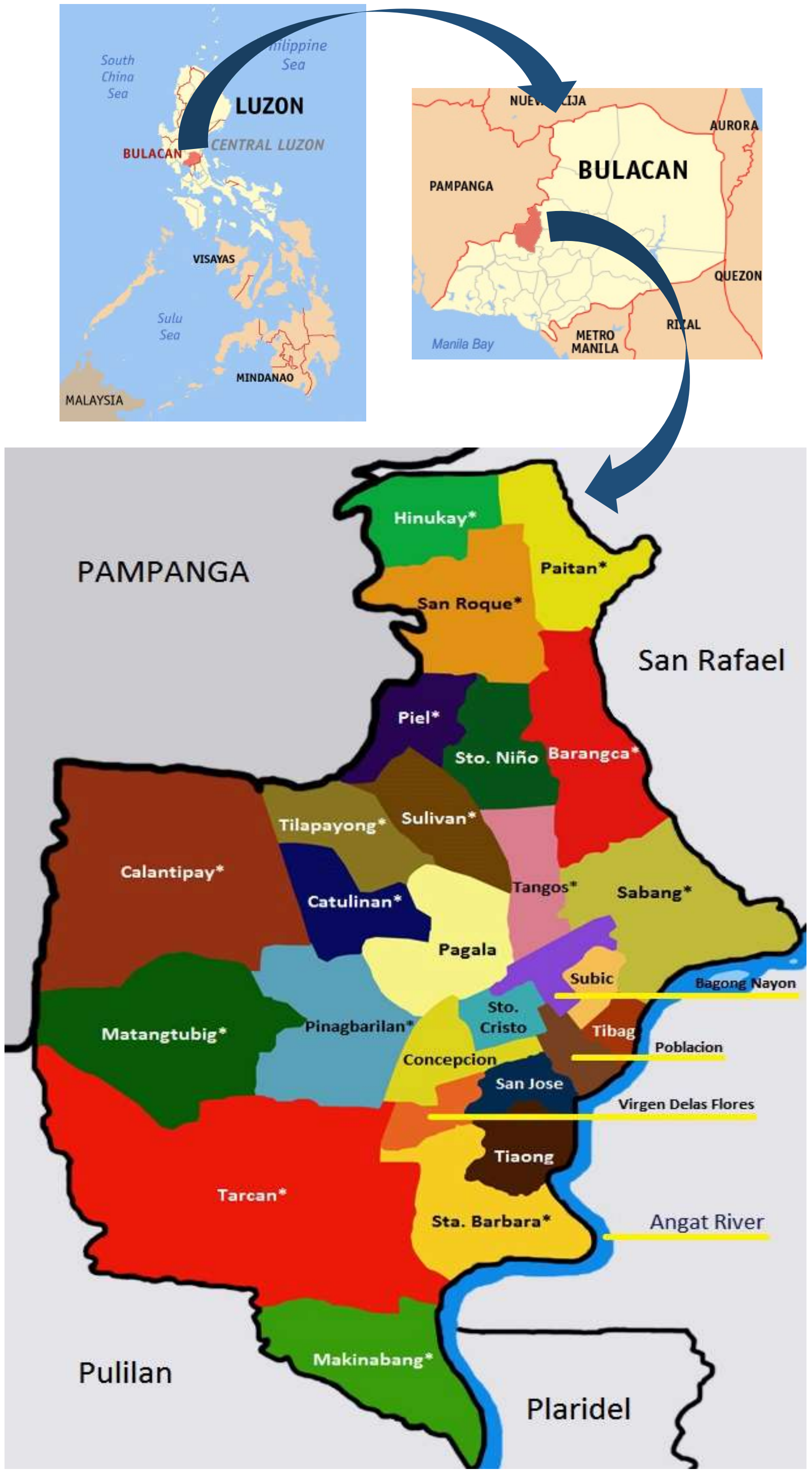

Figure 4. Map of Baliwag, Bulacan
Source: https://baliwag.gov.ph, https://en.wikipedia.org/wiki/Baliuag,_Bulacan

Baliwag is a fully irrigated municipality, with all of its rice irrigation coming from the Angat River to the southwest and serviced by the National Irrigation Systems (NIS). There also farms which are serviced by Shallow Tube Wells or Open Surface Pumps (STW/OSP) by the government, with a service area of 30 hectares.

Description of Respondents

The study was composed of 40 combine harvester adopters and 40 non-adopters. From the 18 agricultural barangays, only Pagala and Sto Nino were not represented. The asterisks in Figure 4 indicate the barangays in which the farmer respondents were located. The barangay with the most number of respondents was Tarcan with 13 rice farmers while the barangays with the smallest number was Tangos and Piel which was each represented by one farmer (Table 2). Tarcan and Matangtubig had the highest number of non-adopter respondents (11) while Barangca had the largest number of combine harvester adopter respondents (7). It should be noted that the barangays which have the highest proportion of adopter respondents were located in the northern part of the town. This may be due to the large number of combine harvester adopters in these barangays due to the increasing popularity of combine harvesting due to their proximity to San Rafael, which has about 80 percent combine harvester adoption rate. This was according to the provincial agriculturist office of Bulacan.

Of the 40 adopters, 27 farmers adopted combine harvesters for both seasons. The number of partial adopters –farmers who adopted combine harvesters for only one season- were 3 for the dry season and 10 for the wet season.

Table 2. Number of farmers by combine harvester adoption and by barangay, 80 farmer-respondents, Baliwag, Bulacan, 2016

BARANGAY	ADOPTER	NON-ADOPTER
	Number of farmers	
Calantipay	5	7
Tarcan	2	11
Catulinan	4	2
Pinagbarilan	2	1
Makinabang	2	1
Matangtubig	1	11
Tangos	-	1
Sta Barbara	-	4
Tilapayong	2	1
Sabang	1	1
Piel	1	-
Sullivan	2	-
Barangca	7	-
Hinukay	3	-
Paitan	3	-
San Roque	5	-
TOTAL	40	40

Table 3 shows the classification of the farmer respondents by harvesting method. The majority of the respondents for both seasons did not adopt combine harvesters, as represented by the higher number of reaper and manual users combined during both seasons. Seven more farmers also adopted combine harvesters during the wet season. This was because of the increase in the partial adopters during this season. More farmer respondents wanted to finish harvesting palay before it got caught by storms, heavy rains or strong winds, which are typically present during the wet season.

The presence of storms and rains during the wet season increased water elevation levels in the fields. Moreover, strong winds during this season flattened the palay, which

Table 3. Distribution of farmers by season and by harvesting method, 80 farmer-respondents, Baliwag, Bulacan, 2016

HARVESTING METHOD	DRY SEASON		WET SEASON	
	Number	Percent	Number	Percent
Combine Harvester	30	37.50	37	46.25
Reaper	22	27.50	8	10.00
Manual	28	35.00	35	43.75
TOTAL	80	100.000	80	100.00

the farmers refer to as *dapang pala*y. These reasons made farms inaccessible and impractical to reaper harvesting, decreasing the number of reaper adopters during the wet season. Because of this, most of them resort to manual harvesting.

Socioeconomic Characteristics

The socioeconomic characteristics for both combine harvester adopters and non-adopters can be considered homogeneous - with the exception of gender, non-rice income, and land (Table 4). Female farmers compose 32.5 percent of non-adopters in comparison to 15 percent female farmers of adopters. Non-adopters had a higher mean non-rice income per year of about PhP 20,279.6 more than adopters. It should be noted that non-rice income included farm income of other crops or livestock other than rice, and as well as off-farm income.

It should be noted that the farmers in this study did not necessarily do farming work. This was because of the popularity of hiring labor in the municipality to the work in rice production and the prevalence of *porsyentuhan*, in which farm-caretakers maintain the farm for a share of the gross harvest. However, farmers in this study were the primary

Table 4. Distribution of farmers by combine harvester adoption and by socioeconomic characteristic, 80 farmer respondents, Baliwag, Bulacan, 2016

SOCIO-ECONOMIC CHARACTERISTIC	ADOPTERS		NON-ADOPTERS		MD[a]
	Number	%	Number	%	
Age Distribution					
Below 40	1	2.5	2	5.0	
40-49	8	20.0	10	25.0	
50-59	11	27.5	9	22.5	
60-69	14	35.0	10	25.0	
70 and above	6	15.0	9	22.5	
Total	40	100.0	40	100.0	
Mean	58.9		59.0		-0.1
Minimum	39.0		38.0		
Maximum	85.0		84.0		
Years of Formal Schooling					
1 to 6	12	30.0	13	32.5	
7 to 10	11	27.5	12	30.0	
11 to 14	15	37.5	15	37.5	
14 and above	2	5.0	0	0.0	
Total	40	100.0	40	100.0	
Mean	10.1		9.2		0.8
Minimum	5.0		3.0		
Maximum	15.0		14.0		
Gender					
Male	34	85.0	27	67.5	
Female	6	15.0	13	32.5	
Total	40	100.0	40	100.0	
Civil Status					
Single	0	0.0	2	5.0	
Married	38	95.0	33	82.5	
Widowed	2	5.0	5	12.5	
Total	40	100.0	40	100.0	
Household Size					
1 to 3	9	22.5	12	30.0	
4 to 7	28	70.0	22	55.0	
8 to 11	2	5.0	3	7.5	
12 and above	1	2.5	3	7.5	
Total	40	100.0	40	100.0	
Mean	5.0		5.2		-0.1
Minimum	2.0		1.0		
Maximum	21.0		14.0		

Table 4. Continued…

Tenure					
Owner-operator	23	57.5	24	60.0	
Part-owner	2	5.0	3	7.5	
Leasehold	15	37.5	13	32.5	
Share-tenant	0	0.0	0	0.0	
Total	40	100	40	100	
Farming Experience					
Below 20	3	7.5	4	10.0	
20-29	13	32.5	10	25.0	
30-39	10	25.0	13	32.5	
40-49	6	15.0	5	12.5	
50-59	6	15.0	5	12.5	
60 and above	2	5.0	3	7.5	
Total	40	100.0	40	100.0	
Mean	32.8		34.5		-1.7
Minimum	8.0		6.0		
Maximum	60.0		66.0		
Membership in Cooperatives/Associations					
Yes	12	30.0	11	27.5	
No	28	70.0	29	72.5	
Total	40	100.0	40	100.0	
Attendance to Seminars/On-Farm Trials Regarding Combine Harvesters					
Yes	3	7.5	3	7.5	
No	37	92.5	37	92.5	
Total	40	100.0		100.0	

[a]Mean difference between adopters and non-adopters

decision makers and managers of the farm. Thus, farmers in this study can be classified as farmer-managers.

The average farm size of non-adopters was also higher by 0.7 hectares, though this may be caused by the presence of the two 16-hectare non-adopter rice farms which may significantly affect its average. Farm size indicated in this study includes all land managed by the farmer. It was also found out that there was no significant difference in the mean farm size for both adopters and non-adopters using the t-test. This analysis was also conducted on the rest of the socioeconomic characteristics, and it was found out that there were no significant differences in the means of these variables.

An interesting characteristic worth pointing out was the low attendance to seminars or on-farm trials regarding combine harvesters. Rice farmers mostly got their knowledge about combine harvesters from fellow farmers, technicians and combine harvester operators. Even though the seminars conducted about rice farming in the municipality partially discussed combine harvesters, the local government conducted very few seminars and on-farm trials specifically about this machinery.

Seed Type

The types of rice seeds used by the farmer respondents were hybrid, inbred and self-pollinated (Table 5). Hybrid seeds are the first filial (F1) generation of a cross of two genetically different rice varieties. These seeds take advantage of hybrid vigor to produce higher yields than other seed types (Virmani & Sharma, 1993). According to Bordey et. al. (2016), inbred seeds are those are those that underwent formal seed certification from a national agency (e.g., registered or certified seeds). These seeds are considered to have less mixture rate and have higher germination rate and resistance to pest and diseases than self-pollinated seeds. Lastly, self-pollinated inbred seeds or farmers' seeds are those "grown and kept by the farmers for planting in the next cropping season" (Bordey et al., 2016).

Table 5. Distribution of farmers by combine harvester adoption, by harvesting method, and by seed type, 80 farmer respondents, Baliwag, Bulacan, dry and wet season, 2016

SEED TYPE	COMBINE		NON-ADOPTER					
			Reaper		Manual		Total	
	No.	%	No.	%	No.	%	No.	%
Dry Season								
Hybrid	9	30.00	4	18.18	3	10.71	7	14.00
Inbred	21	70.00	18	81.82	22	78.57	40	80.00
Self-pollinated					3	10.71	3	6.00
Total	30	100	22	100	28	100	50	100
Wet Season								
Hybrid	1	2.70	1	12.50	3	8.57	4	9.30
Inbred	36	97.30	7	87.50	29	82.86	36	83.72
Self-pollinated					3	8.57	3	6.98
Total	37	100	8	100	35	100	43	100

[a]number of farmers

The use of hybrid seeds, although claimed to produce higher yields than the other types, were not popular in Baliwag because of its high acquisition and input costs. It was significantly less popular during the wet season because of the presence of natural calamities t in this season that may damage the palay.

For the dry season, thirty percent of combine harvester adopters used hybrid rice while the rest used inbred rice. Only 14 percent of non-adopters, however, used hybrid rice while the majority of them used inbred. There were still non-adopters who use open-pollinated seeds, which came from them or other farmers. All of the farmers who used open-pollinated seeds practiced manual harvesting. During the wet season, only a single adopter out of 37 used hybrid seeds while the rest used inbred. Four farmers or 9.3 percent of non-adopters used hybrid while the rest used inbred and open-pollinated seeds.

Farm Inputs

The usage of farm inputs was analyzed to determine whether there were differences in the usage of these input among the three rice harvesting practices. The results of the analysis are shown in Table 6. Using ANOVA, it was shown that for the dry season, the inputs that had significant differences were fertilizers, hired labor, family labor, total labor, and fuel. The same was true for the wet season, with the exception of fertilizers.

Table 6. Input usage per hectare by harvesting method, 80 farmer respondents, Baliwag, Bulacan, dry and wet season, 2016

FARM INPUT	COMBINE	REAPER	MANUAL	F-COMPUTED
Dry Season	(n=30)	(n=22)	(n=28)	
Seeds (kg/ha)	85.47	98.91	107.43	1.39
Fertilizer (bags/ha)	7.76	7.05	6.35	2.55*
Labor				
Hired Labor (mandays/ha)	12.96	24.02	25.40	21.69***
Family Labor (mandays/ha)	0.64	3.96	5.61	3.99**
Total Labor	13.60	27.98	31.01	35.91***
Fuel (lit/ha)	11.52	12.74	22.57	2.86*
Wet Season	(n=37)	(n=8)	(n=35)	
Seeds (kg/ha)	105.18	88.97	102.21	0.35
Fertilizer (bags/ha)	6.40	6.39	5.76	0.75
Labor				
Hired Labor (mandays/ha)	25.92	47.41	42.47	6.76***
Family Labor (mandays/ha)	1.06	6.41	4.65	3.53**
Total Labor (mandays/ha)	26.98	53.82	47.12	11.99***
Fuel (lit/ha)	9.34	15.73	22.47	4.52**

The fertilizer usage of combine users during the dry season was the highest among the three harvesting methods. This may be caused by the larger proportion of combine harvester adopters who use hybrid seeds (Table 5) which need to have larger amounts of fertilizer in order for them to grow properly. Fertilizer usage was not significant during the wet season because very few farmers used hybrid seeds during that season.

Fuel usage for manual harvesters was higher than combine and reaper because many of them preferred to do land preparation by themselves or by their families rather than hiring labor. They used their own hand tractors to prepare the land, causing the higher fuel usage.

The higher fuel usage was related to the higher family labor usage of manual harvesters in comparison to combine harvesters. Reapers also had a higher family labor than combine users. This was because of the preference combine users to hire labor rather than doing farm work themselves or by their families.

Total labor was significant among the three harvesting methods at a 1 percent level. This was caused by the differences in the usage of hired labor, which was also significant at a 1 percent level. It was shown that for both seasons, the hired labor usage of combine users was nearly half of reaper and manual. This w because of the significantly less harvesting and threshing labor usage of combine harvesting, which uses only uses 0.60 man-days per hectare in comparison to both reaper and manual harvesting which uses 13.94 and 15.93 man-days per hectare respectively. Combine harvesting only requires 3 people to operate the combine harvester and can harvest a hectare of palay in 1-2 hours. Reapers and manual harvesting, on the other hand, requires the use of 10-20 harvester laborers per hectare and takes about 1-2 days/hectare to harvest. It should also be noted that hired labor was higher during the wet season because more farmers practice transplanting. This practice requires more labor usage than direct seeding -the common practice during the dry season. Farmers do not use direct seeding because of the risk of the seeds getting flooded, scattered by strong winds, and be eaten by pests.

Comparison of Yield, Price, and Production Value

The yield, price, and production value of the farmer respondents were analyzed to see if there were significant differences in these variables among the three harvesting methods. The production value, which is equivalent to the total returns of the farmers, was computed by multiplying yield by the price. These values were also computed to determine harvesting cost which was based on a percentage of the gross harvest (to be discussed in the succeeding section).

Harvesting methods may affect yield because there is grain loss during the cutting of crops; threshing and cleaning; and crop and grain handling. Grain loss may be more apparent on manual and reaper harvesting because palay needs to be separately harvested and threshed which increases the chance of having more grain losses. Combine harvesting, on the other hand, combines harvesting and threshing in one process.

Dry Season

For the dry season (Table 7), it was found out that yield and production value is significant at a 10 percent level. Price, on the other hand, was very significant among the three harvesting methods at a 1 percent level. The yield of combine users was higher than the users of the other two harvesting methods. This was consistent with the results of Llorente (2016) and Santos (2015). Santos attributed this difference primarily to the fewer losses because of the more efficient harvesting operation of the combine harvester. However, it should be noted that other factors may also significantly affect the difference in yield. One reason may be the higher proportion of adopters who use hybrid seeds, which, as discussed in the previous section, attributed to produce higher yields. Other factors may also include the difference in the level of inputs and the managerial skill of the farmers.

Table 7. Yield, price, and production value per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, dry season, 2016

ITEM	COMBINE (n=30)	REAPER (n=22)	MANUAL (n=28)	F-COMPUTED
Yield (kg/ha)	5,462.89	5,089.87	4,607.18	3.06*
Price (PhP/kg)	17.22	18.89	17.18	9.68***
Production Value (Php/ha)	94,138.54	96,039.58	80,016.88	3.06*

***, **, and * - significant at 1%, 5%, and 10% level, respectively

Surprisingly, it was found that the price of reaper users (PhP 18.89 per kg) was significantly higher at a 10 percent than combine (PhP 17.22 per kg) and manual (PhP 17.18 per kg). The first reason for this difference may be the preference of rice buyers for threshed (reaper and manual) palay. One reason for this can be attributed to the fact that combine harvested palay in Baliwag may contain significantly more chaff than threshed palay. Rice buyers prefer palay with less chaff because they contain more grains which can be milled to produce head rice yield. This was supported by the perception of farmers that threshed palay is cleaner and has less chaff than combine harvested palay (Table 25) and well as their perception that combine harvested palay has a lower price than threshed palay

(Table 27). This will be further discussed in the section about the attitudes and perceptions analysis. It was discovered in a study by Chandrajith et al. (2016) in Sri Lanka that chaff content in long and short paddy significantly differs with different models of combine harvesters. Thus, it could be said that, combine harvesters serviced in Baliwag may have produced more chaff than other types of combine harvesters. This may be caused by the inadequate and inefficient winnowing implements or blowers of the serviced combine harvesters.

Another reason for the price difference may be caused by the difference in the post-harvest practices of the farmer respondents. Non-adopter farmers in Baliwag commonly practice field drying or *belita* where the palay is first left in the field after being cut for 1-2 days in order for it to dry before being threshed. This reduces the need for palay to be dried after being threshed if its moisture content is low enough. Because of this, it can be directly sold to the rice buyers after threshing. On the other hand, because combine harvesting harvests and threshes the palay in one process, the harvested grains still have high moisture content. Adopters typically sell the palay at a lower price directly after harvesting. This is because rice buyers still need to dry them before milling. The rest of the farmers dried the palay themselves before selling. However, since most of them did not have adequate space for sun drying, they did it on the sides of the roads. This practice also yields higher post-harvest losses. Mechanical dryers were rarely used in Baliwag because of the inadequate machinery available in the area.

However, these reasons do not adequately explain the higher price of reapered palay than manually harvested palay. The reason for their difference was because of the post-harvest practices of the farmers related to the nature of the two combine harvesting methods. Both groups of farmers field dried their palay. However, there were differences in how they do it. In manual harvesting, palay stalks are usually cut and laid the fields unevenly. In reaper harvesting, however, the stalks are cut more evenly by the machine. Because of this, the accompanying palay gatherers or *mang-iipon* can also lay the palay stalks more evenly in the fields. As a result, reapered palay can be field dried more evenly and more quickly. Manual rice takes about 3-4 days to field dry in comparison to the reaper's two days. The difference in days may also risk the palay to be more exposed to being overheated, be eaten by pests, and may have more risk being rained -especially during the wet season. Another significant post-harvest reason was the better storage facilities of some reaper-respondents. Some of these farmers typically sell palay late in the harvesting season. Because of this, they earn a higher price for their palay.

The reasons previously stated, however, were inadequate to conclude that reapered rice is more expensive. This was because other factors such as the use of better management practices and better varieties of rice may have a more significant effect on this variation.

The production value was equal to the product of yield and price. This was also equivalent to the total returns of the farmers. Manual harvesters had a lower production value than both combine users and reaper users. This was because of their lower yields and lower price than the other two harvesting methods. However, this difference was only significant between reapers. Reapers surprisingly had a higher production value than combine adopters, although it was shown to be insignificant. Even though combine harvester users have higher mean yield, the significant difference in the price of palay for reaper users offsets this.

Wet Season

During the wet season, the differences in the yield, price and production value of the three harvesting methods were found to be insignificant (Table 8). This was caused by the high variance in the yield on both adopters and non-adopters because of the presence of torrential rains, storms, and strong winds during the wet season. These were also the reasons why the yield and price of the farmer respondents were lower during the wet season. These calamities damaged the palay stalks, decreasing the yield of palay. The palay's price was also affected because of the higher moisture content and the presence of dirt and mud in the palay, making it unattractive to rice buyers. A reliable comparison between the three harvesting methods may also be inadequate during this season because of the significantly lower number of respondents of reapers (8) compared to the other two practices.

Because of the high variance of the palay yields during the wet season, it would be more reliable to compare the differences between the variables during the dry season. It was shown that adopters have higher yields than reapers and manual harvesters. It was also shown that price was higher for reapers users. However, it is inappropriate to conclude that harvesting method had a significant effect on these variables. It should be reiterated that this analysis was not intended to determine the effects of harvesting on yield and price, but

Table 8. Yield, price, and production value per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, wet season, 2016

ITEM	COMBINE (n=37)	REAPER (n=8)	MANUAL (n=35)	F-COMPUTED
Yield (kg/ha)	4,202.38	4,440.27	3,947.22	0.68
Price (PhP/kg)	17.07	16.25	16.47	0.79
Production Value (PhP/ha)	71,981.97	71,555.04	65,588.85	0.71

only a mere comparison to determine if there were differences in these variables. Thus, it is recommended that separate studies be done on the impact of harvesting methods on the yield and price of palay.

Comparison of Harvesting Cost

In this study, harvesting cost included the cost of harvesting and threshing. It should first be noted that none of the respondents owned combine harvesters. All of the adopters, instead, hired combine harvesting services from private individuals and cooperatives. Because of this, the costs for combine harvesting consisted of the rental payment for the harvesting service. The harvesting costs for manual harvesting consisted of the payment for the harvester-laborers or *manggagapas*. The costs for reaper harvesting consisted of the payment for the reaper rentals and their accompanying palay gatherers or *taga-ipon*.

The payment schemes for harvesting was on a percentage of gross harvest. Because of this, higher yields, price, and consequently higher production value will constitute higher costs. However, the percentage payments of the three harvesting methods were significantly different. Hiring combine harvesters generally cost 10 percent of the gross harvest. Hiring reapers cost about PhP 2,000 to 2,200 per hectare and an additional payment of 1 cavan per 12 cavans harvested (8.33 percent of gross harvested) for the palay gatherers. Manual harvesters normally cost one cavan for every nine cavans harvested or about 11.11 percent of the total harvest. Threshing typically cost around 7 percent of the gross harvest.

The difference in the percentage payment share was the cause of the lower harvesting costs of combine harvesting than both reaper and manual for both seasons (Table 9 and 10). The difference in harvesting costs was also found to be significant using t-test analysis. Despite manual harvesting having significantly lower production than the other two methods, it still had a significantly higher cost than combine harvesting. Reapers users had the highest total harvesting costs because of the reaper rental costs and their higher production value than the other harvesting methods. The higher production value of reapers was also the cause of the significantly higher threshing cost than manual harvesters despite both of them having relatively the same thresher payment share (7 percent of gross harvest).

Table 9. Harvesting costs per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, dry season 2016

HARVESTING COST	COMBINE (n=30)	REAPER (n=22)	MANUAL (n=28)	F-COMPUTED
		In PhP/ha		
Cash Cost				
Reaper Rental	0.00	2,045.68	0.00	
Total Cash Cost	0.00	2,045.68	0.00	
Non-cash Costs				
Combine Harvester's Share	8,683.22	0.00	0.00	
Harvester-Laborer's	0.00	8,373.42	8,959.77	
Thresher's Share	0.00	6,912.59	5,717.41	
Total Non-cash	8,683.22	15,286.01	14,677.18	24.55***
TOTAL	86,83.22	17,331.69	14,677.18	34.53***

Table 10. Harvesting costs per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, wet season 2016

HARVESTING COST	COMBINE (n=37)	REAPER (n=8)	MANUAL (n=43)	F-COMPUTED
		In PhP/ha		
Cash Cost				
Reaper Rental	0.00	2,144.30	0.00	
Total Cash Cost	0.00	2,144.30	0.00	
Non-cash Costs				
Combine Harvester's Share	6,646.53	0.00	0.00	
Harvester-Laborer's	0.00	6,186.48	7,349.80	
Thresher's Share	0.00	5,323.43	4,769.78	
Total Non-cash	6,646.53	11,509.91	12,119.58	24.12***
TOTAL	6,646.53	13,654.21	12,119.58	27.81***

The cost-efficiency of the three harvesting methods were also analyzed. This took into account the yield differences among the farmer respondents using the three harvesting methods. According to Bordey et al. (2016), “the lower the cost of production per unit of output, the more cost-efficient a rice production system is.” Therefore, lower costs of harvesting per unit of output mean a higher cost-efficiency for a given harvesting method. This was calculated by dividing the total cost of harvesting by yield level for each farmer.

Table 11 and 12 shows that combine harvesting was indeed more cost-efficient than both reaper and manual for both the dry and wet season. The differences in the cost-efficiency of combine harvesting to the other two methods were also found to be significant using t-test. Of the three harvesting methods, reaper harvesting was the least cost-efficient. Reapers cost 3.44 and 3.13 per kg during the dry season and wet season respectively. This was higher than manual harvesting which cost PhP 3.16 per kg for the dry season and PhP

Table 11. Harvesting costs per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, dry season 2016

HARVESTING COST	COMBINE (n=30)	REAPER (n=22)	MANUAL (n=28)	F-COMPUTED
		In PhP/ha		
Cash Cost				
Reaper Rental		0.43		
Total Cash Cost		0.43		
Non-cash Costs				
Combine Harvester's Share	1.60			
Harvester-Laborer's Share		1.65	1.93	
Thresher's Share		1.36	1.23	
Total Non-cash	1.60	3.01	3.16	405.38***
TOTAL	1.60	3.44	3.16	465.82***

Table 12. Harvesting costs per hectare of farmers classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, wet season 2016

HARVESTING COST	COMBINE (n=37)	REAPER (n=8)	MANUAL (n=43)	F-COMPUTED
		In PhP/ha		
Cash Cost				
Reaper Rental		0.43		
Total Cash Cost		0.43		
Non-cash Costs				
Combine Harvester's Share	1.58			
Harvester-Laborer's Share		1.69	1.93	
Thresher's Share		1.39	1.23	
Total Non-cash	1.58	3.08	3.16	208.11***
TOTAL	1.58	3.51	3.16	220.72***

3.04 per kg for the wet season. Although reapers had lower non-cash costs due to the lower payment share for laborers, the cost of reaper rentals significantly increased it. This increased the cost of reaper harvesting by PhP 0.43 and PhP 0.51 per kg during the dry season and wet season respectively.

Cost-efficiency can also be interpreted as the percentage payment of harvesting multiplied by the price. This was because harvesting costs were paid as shares of the total harvest, with the exception of reaper rentals. The cost efficiency of reapers which were equal to the percentage payment of harvesting multiplied by the price with the addition of reaper rental payment divided by yield. With this in mind, the mean percentage payment was computed by dividing cost-efficiency with the prices indicated in Table 6, 7, 8 and 9.

For the dry season, the mean percentage payment for combine harvesters was 9.29 percent, significantly lower than manual which was at 18.39 percent and reaper which was at 18.21 percent. The reaper percentage payment was calculated as the sum of the reapers non-cash costs per kg is PhP 15.93 and its rental cost (PhP 0.43 per kg). The main reason for the difference in the percentages was that non-combine harvesting separately harvests and threshes the palay, needing a separate payment for each process. Moreover, the amount of labor required was significantly lower for combine harvesting, as previously discussed.

Price also affects cost-efficiency. Based on the formula, a higher price will entail a higher cost-efficiency. Because of the significantly higher palay price of reaper users, their cost-efficiency became the highest among the three. This was also the reason why reapers had higher cost-efficiency despite having lower percentage payments. However, the percentage payments for the three methods were the most significant factor in determining cost-efficiency. Although reaper users had a higher price of palay, combine adopters still had a lower cost per kilogram because of the significantly lower percentage harvesting payment.

The mean percentage harvesting payments were also computed for the wet season. The values were similar to the dry season. The percentage values are 9.26, 19.26 and 18.46 of combine, reaper, and manual harvesters respectively. These values were similar to the dry season. Interestingly, reapers had the highest percentage payment. This may be due to the increased cost of hiring reapers during the wet season. However, it should be noted that this should be carefully interpreted because there were only eight respondents who used reapers during this season. Thus, it can be said that the primary cause for the difference in cost efficiency in the wet season was also the difference in the percentage payments of harvesting.

For both seasons, it can be concluded that although yield, price, and thus production affects total harvesting costs per hectare and cost-efficiency, the percentage payments of each of the harvesting methods were more significant in its determination. Combine harvesters had lower percentage payments than both manual and reaper. This was because less labor was required for combine harvesting and because it harvests and threshes the palay simultaneously. Non-combine harvesting (manual and reaper), on the other hand, had higher labor requirement. Palay harvested using these methods also needs to separately threshed, increasing harvesting cost.

Effect of Adopting Combine Harvesters

Comparison of Net Farm Income

To determine the financial effects of adopting combine harvesting, the net of farmers was first computed and compared between harvesting methods. The costs and return items for the dry and wet season can be found at Appendix Table 4.1 and 4.2. It was shown that for the dry and wet season, combine harvesters had higher net farm income than reaper and manual. The main reason for this difference was the significantly lower harvesting costs of combine harvesters. Harvesting costs comprised 18.89 percent of the total costs for combine harvesters during the dry season, in comparison to reapers and manual which was at 35.59 percent and 31.83 percent respectively. The percentages were similar during the wet season where combine harvesting comprised 15.62 percent of the total costs in comparison to manual and reaper which was at 30.17 percent and 27.26 percent respectively.

It was also shown that manual harvesters have significantly lower net farm incomes than reaper and combine (Table 13). This was because of their lower yields and palay price. Reapers had smaller differences between combine; this was because of their higher palay prices and their lower non-cash cost items. The differences between the net farm incomes were significant at a 1% level during the dry season. During the wet season, the values insignificant, however. This was because of the presence of calamities during the wet season which causes a high variance in the yields of the farmers.

Table 13. Net farm income of farmers classified by harvesting method and by season, 80 farmer respondents, Baliwag, Bulacan, 2016

SEASON	COMBINE		REAPER		MANUAL		F-COMPUTED
	No.	PhP/ha	No.	PhP/ha	No.	PhP/ha	
Dry Season	30	48,164.86	22	47,340.82	28	33,907.38	5.48***
Wet Season	37	29,423.95	8	26,290.70	22	21,128.88	1.70

Partial Budget Analysis

The financial effects of adopting combine harvesting are shown in the partial budget analysis (Tables 14-21). Only the reduced harvesting costs and added combine harvesting costs were the items used in this analysis. Although it was shown that there are differences in the yields and price between the users of the three harvesting methods, it was inadequate to conclude that their respective harvesting methods had a significant influence on these variables. Other factors may be more significant for those differences.

Table 14. Partial budget analysis per hectare of switching to combine harvesting from reaper, 30 combine and 22 reaper farmer respondents, Baliwag, Bulacan, dry season 2016

GAINS	VALUE (PhP/ha)	LOSSES	VALUE (PhP/ha)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	8,683.22
Total Added Returns (I)	-	Total Added Costs (III)	8,683.22
REDUCED COSTS		REDUCED RETURNS	
Reaper Harvesting Cost	17,331.69	None	-
Total Reduced Costs (II)	17,331.69	Total Reduced Returns (IV)	-
SUBTOTAL (A)	17,331.69	SUBTOTAL (B = III + IV)	8,683.22
NET GAIN (A-B) 8,648.47			

Table 15. Partial budget analysis per hectare of switching to combine harvesting from manual, 30 combine and 28 manual farmer respondents, Baliwag, Bulacan, dry season 2016

GAINS	VALUE (PhP/ha)	LOSSES	VALUE (PhP/ha)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	8,683.22
Total Added Returns (I)	-	Total Added Costs (III)	8,683.22
REDUCED COSTS		REDUCED RETURNS	
Manual Harvesting Cost	14,677.18	None	-
Total Reduced Costs (A)	14,677.18	Total Reduced Returns (IV)	-
SUBTOTAL (A)	14,677.18	SUBTOTAL (B = III + IV)	8,683.22
	NET GAIN (A-B)	5,993.96	

Table 16. Partial budget analysis per hectare of switching to combine harvesting from reaper, 37 combine and eight reaper farmer respondents, Baliwag, Bulacan, wet season, 2016

GAINS	VALUE (PhP/ha)	LOSSES	VALUE (PhP/ha)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	6,646.53
Total Added Returns (I)	-	Total Added Costs (III)	6,646.53
REDUCED COSTS		REDUCED RETURNS	
Reaper Harvesting Cost	13,654.21	None	-
Total Reduced Costs (II)	13,654.21	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	13,654.21	SUBTOTAL (B = III + IV)	6,646.53
	NET GAIN (A-B)	7,007.68	

Table 17. Partial budget analysis per hectare of switching to combine harvesting from manual, 37 combine and 35 manual farmer respondents, Baliwag, Bulacan, wet season, 2016

GAINS	VALUE (PhP/ha)	LOSSES	VALUE (PhP/ha)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	6,646.53
Total Added Returns (I)	-	Total Added Costs (III)	6,646.53
REDUCED COSTS		REDUCED RETURNS	
Manual Harvesting Cost	12,119.58	None	-
Total Reduced Costs (II)	12,119.58	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	12,119.58	SUBTOTAL (B = III + IV)	6,646.53
NET GAIN (A-B) 5,473.05			

Table 18. Partial budget analysis per kg of switching to combine harvesting from reaper, 30 combine and 22 reaper farmer respondents, Baliwag, Bulacan, dry season 2016

GAINS	VALUE (PhP/kg)	LOSSES	VALUE (PhP/kg)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	1.6
Total Added Returns (I)	-	Total Added Costs (III)	1.6
REDUCED COSTS		REDUCED RETURNS	
Reaper Harvesting Cost	3.44	None	-
Total Reduced Costs (II)	3.44	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	3.44	SUBTOTAL (B = III + IV)	1.6
NET GAIN (A-B) 1.84			

Table 19. Partial budget analysis per kg of switching to combine harvesting from manual, 30 combine and 28 manual farmer respondents, Baliwag, Bulacan, dry season 2016

GAINS	VALUE (PhP/kg)	LOSSES	VALUE (PhP/kg)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	1.6
Total Added Returns (I)	-	Total Added Costs (III)	1.6
REDUCED COSTS		REDUCED RETURNS	
Manual Harvesting Cost	3.16	None	-
Total Reduced Costs (II)	3.16	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	3.16	SUBTOTAL (B = III + IV)	1.6
NET GAIN (A-B) 1.56			

Table 20. Partial budget analysis per kg of switching to combine harvesting from reaper, 37 combine and 8 reaper farmer respondents, Baliwag, Bulacan, wet season 2016

GAINS	VALUE (PhP/kg)	LOSSES	VALUE (PhP/kg)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	1.58
Total Added Returns (I)	-	Total Added Costs (III)	1.58
REDUCED COSTS		REDUCED RETURNS	
Reaper Harvesting Cost	3.51	None	-
Total Reduced Costs (II)	3.51	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	3.51	SUBTOTAL (B = III + IV)	1.58
NET GAIN (A-B) 1.93			

Table 21. Partial budget analysis per kg of switching to combine harvesting from manual, 37 combine and 35 manual farmer respondents Baliwag, Bulacan, wet season 2016

GAINS	VALUE (PhP/kg)	LOSSES	VALUE (PhP/kg)
ADDED RETURNS		ADDED COSTS	
None	-	Combine Harvesting Cost	1.58
Total Added Returns (I)	-	Total Added Costs (III)	1.58
REDUCED COSTS		REDUCED RETURNS	
Manual Harvesting Cost	3.16	None	-
Total Reduced Costs (II)	3.16	Total Reduced Returns (IV)	-
SUBTOTAL (A = I + II)	3.16	SUBTOTAL (B = III + IV)	1.58
NET GAIN (A-B) 1.58			

The reduced costs were the mean harvesting costs of reaper and manual. The added costs were the costs for combine harvesting. This was computed by multiplying the respective mean production values of reapers and manual harvesters by the percentage share payment of combine harvesting calculated in the previous section (Dry: 9.29%, Wet: 9.26%). This took into account the differences in the yield, price and production value of the users of the three harvesting methods.

On a per hectare basis, the results of the partial budget analysis are shown in Tables 14 to 18. The results of the analyses showed that for both seasons, adopting combine harvesting from reaper and manual would yield positive net gains and thus be more profitable. To see the percentage increase in net farm income in adopting combine harvesters, the percentage of net gains in comparison to net farm income for reaper and manual during the two season was also computed. Switching to combine from reapers and manual will increase net farm income by 17.76 percent and 21.36 percent respectively. The percentage increase was higher during the wet season where it was shown that adopting combine results to a 26.73 percent and 28.62 percent increase in the net farm income of reapers and manual harvesters respectively. The higher percentage increase in net farm income was because of the lower net farm income during this season.

Partial budget analysis was also compared on a per kilogram basis (Tables 18-21). The reduced costs were the harvesting costs per kilogram of reapers and manual. The added costs were the mean harvesting cost per kilogram of combine harvesters. It was shown that adopting combine harvesters increases the net farm income by PhP 1.56 to PhP 1.93 per kilogram. The net gain for reapers is higher than manual for both seasons. This is because of the significantly higher costs per kilogram of reaper users. The results were consistent with the study of Bordey et al. (2016) where similar values were found in their partial budget analysis of the harvesting costs per kilogram of palay.

Attitudes and Perception Analysis

Reasons for Adopting and Not Adopting Combine Harvesters

The top two reasons for farmers for adopting combine harvesters during the dry season were that they believe it to be less costly and have a shorter harvesting time, eliminating the need for them to watch over hired harvesters on a longer period. The same reasons were true for the wet season, with the addition of the higher number whom farmers like to harvest palay quickly to prevent it being damaged by storms or strong winds. This reason was significant in increasing the number of combine harvester adopters from 30 during the dry season to 37 during the wet season. All the reasons of farmers for adoption are indicated in Table 22.

Table 22. Distribution of farmers classified by season and by reason for adopting combine harvesters, 40 farmer respondents, Baliwag, Bulacan, 2016

REASON	DRY (n = 30)		WET (n = 37)	
	Number	%	Number	%
Less costly	17	56.67	15	40.54
Harvest palay quickly before the arrival of an incoming storm	-	0	13	35.14
Shorter harvesting time	10	33.33	10	27.03
Less waste	3	10.00	3	8.11
Harvester-laborers were not available	5	16.67	2	5.41
Less labor-intensive	1	3.33	1	2.70
Tested the machine	1	3.33	1	2.70
Joined with the harvesting of a neighboring farm who hired a combine harvester	1	3.33	1	2.70
Owned thresher was damaged	-	0	1	2.70
Do not need to watch over the harvest	-	0	1	2.70

Table 23 shows the reasons why the farmer respondents who use non-combine harvesting (manual and reaper) did not adopt combine harvesters for both the dry and wet season. The top reason was that they do not like harvester-laborers or *manggagapas* to lose their livelihood. This reason was significantly higher than the other reasons because 70 percent and 63 percent of non-adopters during the dry season and wet season chose this reason respectively. Other top reasons indicated that some farmers want their palay to already be field dried when threshed and their traditional and personal preference for manually harvested palay.

Table 23. Distribution of farmers classified by season and by reason for not-adopting combine harvesters, 50 dry season and 43 wet season farmer respondents, Baliwag, Bulacan, 2016

REASON	DRY						WET					
	Manual (n = 28)		Reaper (n = 22)		Total (n = 50)		Manual (n = 35)		Reaper (n = 8)		Total (n = 43)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
So that harvester-laborers would not lose their livelihood	17	60.71	18	81.82	35	70	23	65.71	4	50	27	63
Needed *darak* for owned carabao	-	0.00	1	4.55	1	2	1	2.86	-	0	1	2
No combine harvester was available for hire	-	0.00	-	0.00	-	0	1	2.86	1	12.5	2	5
Lack of knowledge on the machine	-	0.00	2	9.09	2	4	1	2.86	2	25	3	7
So that palay can be field-dried	2	7.14	3	13.64	5	10	1	2.86	3	37.5	4	9
Personal/Traditional preference for manual-threshed palay	4	14.29	-	0.00	4	8	4	11.43	-	0.00	4	9
Combine harvesters can't access field because it is flooded	1	3.57	-	0.00	1	2	2	5.71	-	0.00	2	5
Inaccessible to combine harvesters (sloped area)	1	3.57	-	0.00	1	2	1	2.86	-	0.00	1	2
Owned thresher	3	10.71	-	0.00	3	6	2	5.71	-	0.00	2	5
Afraid that no one will harvest palay if it is flattened	1	3.57	-	0.00	1	2	1	2.86	-	0.00	1	2
Farm capital was loaned from thresher renter	1	3.57	-	0.00	1	2	1	2.86	-	0.00	1	2
Higher price of manually harvested palay	1	3.57	-	0.00	1	2	1	2.86	-	0.00	1	2

Attitudes and Perception Analysis

The farmers were asked different questions about their attitudes and perceptions on various aspects related to combine harvesting. From the 18 questions, four questions were not included because of their unreliability and vagueness of the results of these questions. The remaining 14 questions were then grouped to determine their perception on the benefits of combine harvesting, perception on the technical characteristics of combine harvesting and attitude towards labor displacement caused by combine harvesters. Three questions not related to these were separated as other questions related to combine and manual harvesting. To quantify the overall perception for each of the categories, mean perception scores for each of them were calculated. This was done by dividing the total number of positive answers by the total number of respondents per adopter. It should be reiterated that adopters were those who use combine harvesters in at least one season.

It should be noted that this because this type of analysis aims to quantify qualitative variables (attitudes and perceptions), the results of this analysis may be inconclusive in revealing what the true attitudes and perceptions of the farmer respondents are. There may be other significant aspects of the farmers' attitudes and perceptions that are not in the scope of this analysis. It should also be noted that the questions were only given in a binary Yes or No format, thus how strong or how weak the perception and attitudes of these farmers were not determined in this analysis. However, this analysis is still useful as baseline knowledge about the overall attitudes and perceptions of farmers in this study area and, thus, can be used as a starting point for further related studies.

Based on the farmer's answers, all adopters and non-adopters were aware of that combine harvesting is faster than manual and reaper (Table 24). More than 80 percent of farmers for both adopters and non-adopters also agreed that combine harvesting is less costly -with four more farmers answering yes for the adopters. Interestingly, there was a slight difference indicating that more non-adopters believe that there is more wastage from reaper and combine harvesting.

Table 24. Perception of farmers on the benefits of combine harvesting classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

PERCEPTION	ADOPTER (n=40)		NON-ADOPTER (n=40)	
	Number	%	Number	%
Is combine harvesting faster than manual and reaper				
Yes	40	100.0	40	100.0
No	0	0.0	0	0.0
Uncertain	0	0.0	0	0.0
Mean Perception Score	1		1	
Is combine harvesting less costly				
Yes	37	92.5	33	82.5
No	2	5.0	5	12.5
Uncertain	1	2.5	2	5.0
Mean Perception Score	0.925		0.825	
Is there more wastage from reaper and manual harvesting than combine harvesting				
Yes	25	62.5	28	70.0
No	14	35.0	10	25.0
Uncertain	1	2.5	2	5.0
Mean Perception Score	0.625		0.7	
OVERALL MEAN PERCEPTION SCORE	2.55		2.525	

The mean perception score for the perception on the benefits of combine harvesting is 2.55 for adopters and 2.525 for non-adopters respectively, a relatively similar difference. This means that majority of farmers for both combine and manual harvesters believed that combine harvesting was more beneficial than manual harvesting.

For the perception of the technical characteristics of combine harvesting (Table 25), it could be seen that less than half of farmers for both adopters and non-adopters agreed that combine harvesters cannot harvest flattened palay or *dapang palay*. However, 77.5 percent of farmers agreed that threshed palay is cleaner than combine harvested palay. 65 percent of non-adopters believed that all combine harvested palay contain large amounts of chaff while 30 percent of adopters only believe this so.

The mean perception score for adopters and non-adopters was 1.475 and 1.875 respectively. This means that non-adopters had a more negative perception about the technical characteristics of combine harvesters than adopters.

The majority of farmers for both adopters and non-adopters believed that they need to take care of the livelihoods of laborers (Table 26). Sixty-five percent of adopters believed this while a larger percentage of non-adopters (87.5 percent) also said the affirmative. It should be noted that there were more uncertain answers for adopters in this question. This may mean that more adopters were either undecided or uncertain whether they need to take care of the livelihoods of harvester-laborers.

Table 25. Perception of farmers on the technical characteristics of combine harvesting classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

PERCEPTION	ADOPTER (n=40)		NON-ADOPTER (n=40)	
	Number	%	Number	%
Combine harvesters cannot harvest flattened palay				
Yes	16	40.0	18	45.0
No	22	55.0	11	27.5
Uncertain	2	5.0	11	27.5
Mean Perception Score	0.4		0.45	
Are threshed palay cleaner than combine harvested palay				
Yes	31	77.5	31	77.5
No	9	22.5	7	17.5
Uncertain	0	0.0	2	5.0
Mean Perception Score	0.775		0.775	
Do all combine harvested palay contain large amounts of chaff				
Yes	12	30.0	26	65.0
No	27	67.5	8	20.0
Uncertain	1	2.5	6	15.0
Mean Perception Score	0.3		0.65	
OVERALL MEAN PERCEPTION SCORE	1.475		1.875	

There was also a significant difference about whether farmers agreed that combine harvesters should only be used when there are no harvester-laborers that could be found or if there is an incoming storm. Eighty-five percent of non-adopters agreed with this while only 30 percent of percent of adopter farmers agreed. Lastly, more non-adopters believed that as rice farmers, it was more important to take care of the livelihoods of manual harvester-laborers than increasing their own incomes. Eighty percent of non-adopters believed this in comparison to only 17.5 percent of adopters.

Table 26. Attitude of farmers towards labor displacement caused by combine harvesters classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

ATTITUDE	ADOPTER (n=40)		NON-ADOPTER (n=40)	
	Number	%	Number	%
As a rice farmer, do you need to take care of the livelihoods of manual harvester-laborers				
Yes	27	67.5	35	87.5
No	3	7.5	2	5.0
Uncertain	10	25.0	3	7.5
Mean Attitude Score	0.675		0.875	
If your palay is healthy, is it better to not use combine harvesters in order to prevent labor displacement				
Yes	17	42.5	34	85.0
No	18	45.0	3	7.5
Uncertain	5	12.5	3	7.5
Mean Attitude Score	0.425		0.85	
Combine harvesters should only be used when there are no harvester-laborers that could be found or if there is an incoming storm.				
Yes	12	30.0	34	85.0
No	26	65.0	3	7.5
Uncertain	2	5.0	3	7.5
Mean Attitude Score	0.3		0.85	
As a rice farmer, is it more important to take care of the livelihoods of manual harvester-laborers than increasing your own income.				
Yes	7	17.5	32	80.0
No	25	62.5	5	12.5
Uncertain	6	15	3	7.5
Mean Attitude Score	0.175		0.8	
OVERALL MEAN ATTITUDE SCORE	2.025		2.7	

The mean perception score for the farmers' attitude towards labor displacement caused by combine harvesters was 2.025 for adopters and 2.7 for non-adopters. Based on this, it can be seen that non-adopters had a more negative attitude towards the labor displacement caused by combine harvesters than adopters.

More farmer adopters agreed that it was better to use combine harvesters but give cavans of palay or money as compensation for their loss of work (Table 27). They believed that it was a win-win situation where they have less harvesting costs but still give some cavans or money so that the laborers will not lose too much from labor displacement. On the other hand, more non-adopters disagreed to this since they believed that handing out doles was not right. The majority of them believed that the laborers should earn it. Moreover, they believed that giving out doles was only temporary, and it was impractical to use give them every season.

More non-adopters agreed that their harvester-laborers did their jobs well the last time they hired them. This meant that non-adopters had a more positive perception of the skill of their harvester-laborers. This question was also used as a proxy to determine the perception of the respondents on the skill of manual harvester-laborers. Eighty-five percent and 92.5 percent of both adopters and non-adopters respectively perceived that the price of combine harvested palay was lower than threshed palay. They perceived combined palay to be a peso lower than threshed. This was due to the rice buyers' preference for threshed palay because it was field dried and it was relatively cleaner than combine harvested ones.

Table 27. Other attitudes and perception questions classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

OTHER QUESTIONS	ADOPTER (n=40)		NON-ADOPTER (n=40)	
	Number	%	Number	%
Is it better to use combine harvesters but give cavans of palay or money as compensation for their loss of work				
Yes	31	77.5	15	37.5
No	4	10.0	19	47.5
Uncertain	5	12.5	6	15.0
Mean Perception Score	0.775		0.375	
Did your harvester-laborers do their jobs well the last time you hired them (manual harvester-laborers)				
Yes	25	62.5	38	95.0
No	15	37.5	2	5.0
Uncertain	0	0.0	0	0.0
Mean Perception Score	0.625		0.95	
Is the price of combine harvested palay lower than the price of threshed palay				
Yes	34	85.0	37	92.5
No	5	12.5	3	7.5
Uncertain	1	2.5	0	0.0
Mean Perception Score	0.85		0.925	

Factors Affecting the Adoption of Combine Harvesters

To determine the factors that affect the adoption of combine harvesters, two logistic regression models were used –one for the dry season and another for the wet season. For each season, adopters were classified as those who used combine harvesters for that particular season. Likewise, non-adopters were those that did not use combine harvesters for that season. During the dry season, there were 30 adopters and 50 non-adopters. In the wet season, there were 37 adopters and 43 non-adopters.

The descriptive statistics for the explanators variables were shown in Tables 28 to 32. Generally, for both seasons, there were little differences in their socio-demographic (age, years of schooling, household size) and institutional (member of a cooperative/association, attendance to seminars/on-farm trials related to combine harvesters) characteristics. However, it should be noted that non-adopters had a higher proportion of land owners than adopters, increasing during the wet season. There were differences in the values of their economic characteristics (farm size and non-rice income). Non-adopters generally have larger values for two variables.

Table 28. Descriptive statistics of the continuous explanatory variables of the two logistic regression models, 80 farmer respondents, Baliwag, Bulacan, 2016

VARIABLE	MEAN	STD. DEV.	MIN	MAX
Socioeconomic				
Age (years)	58.95	12.04	38	85
Years of Schooling	9.90	4.00	3	27
Household Size	5.10	3.00	1	21
Non-rice Income (PhP/year)	153,977.30	263,619.90	0	146,0000
Farm size (hectares)	2.10	2.48	0.2	16
Perception and Attitude				
Perception on the benefits of combine harvesting	2.54	0.65	1	3
Perception of the technical characteristics of combine harvesting	1.68	0.92	0	3
Attitude Towards Labor Displacement	2.48	1.45	0	4

Table 29. Mean values of continuous explanatory variables of the dry season logistic regression model classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

VARIABLE	ADOPTER (n=30)	NON-ADOPTER (n=50)	MEAN DIFFERENCE
Socioeconomic			
Age (years)	60.33	58.12	2.21
Years of schooling	10.20	9.72	0.48
Household size	5.13	5.08	0.05
Non-rice income (PhP/year)	147,700.00	157,743.70	-10,043.70
Farm size (hectares)	1.74	2.32	-0.59
Perception and Attitude			
Perception on the benefits of combine harvesting	2.57	2.52	0.05
Perception of the technical characteristics of combine harvesting	1.40	1.84	-0.44
Attitude towards labor displacement	1.27	3.20	-1.93

Table 30. Mean values of continuous explanatory variables of the wet season logistic regression model classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

VARIABLE	ADOPTER (n=37)	NON-ADOPTER (n=43)	MEAN DIFFERENCE
Socioeconomic			
Age (years)	59.14	58.79	0.34
Years of schooling	10.08	9.74	0.34
Household size	5.05	5.14	-0.09
Non-rice income (PhP/year)	149,878.40	157,504.30	-7,625.90
Farm size (hectares)	1.74	2.42	-0.68
Perception and Attitude			
Perception on the benefits of combine harvesting	2.54	2.53	0.01
Perception of the technical characteristics of combine harvesting	1.49	1.84	-0.35
Attitude towards labor displacement	1.59	3.23	-1.64

Table 31. Frequencies of discrete explanatory variables of the dry season logistic regression model classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

VARIABLE	DESCRIPTION	ADOPTER (n=30)	NON-ADOPTER (n=50)	TOTAL
Institutional				
Tenure	Owner/Part-owner	16	36	52
	Otherwise	14	14	28
Member of a cooperative/association	Member	9	14	23
	Otherwise	21	36	57
Attendance to seminars/on-farm trials related to combine harvesters	Attended	3	3	6
	Otherwise	27	47	74
Perception and Attitude				
Perception on the skill of manual harvester-laborers	Yes	16	47	63
	Otherwise	14	3	17

Table 32. Frequencies of discrete explanatory variables of the wet season logistic regression model classified by combine harvester adoption, 80 farmer respondents, Baliwag, Bulacan, 2016

VARIABLE	DESCRIPTION	ADOPTER (n=37)	NON-ADOPTER (n=43)	TOTAL
Institutional				
Tenure	Owner/Part-owner	24	28	52
	Otherwise	13	15	28
Member of a cooperative/association	Member	10	13	23
	Otherwise	27	30	57
Attendance to seminars/on-farm trials related to combine harvesters	Attended	3	3	6
	Otherwise	34	40	74
Perception and Attitude				
Perception on the skill of manual harvester-laborers	Yes	24	39	63
	Otherwise	13	4	17

Regarding their perception and attitudes, there were little differences in both adopters and non-adopters perception on the benefits of combine harvesting. Non-adopters, however, had a more negative perception of the technical characteristics of combine harvesting and had a more negative attitude towards labor displacement caused by combine harvesters. Additionally, more non-adopters perceived that their manual laborers did their jobs well the last time they hired them.

The results of the logistic regression analysis can be found in Table 33 and 34. The value of the likelihood ratio chi-square test for the model was 55.43 and 37.17 for the dry season respectively. This ratio represents the significance of the logistic regression model. The p-values or the probability of obtaining this statistic were both less than the critical value of 0.01. This means that, for both seasons, all the explanatory variables taken together had a significant effect on the adoption decision of rice farmers towards combine harvesters at a 1 percent level in comparison to a model without explanatory variables

Goodness-of-fit-tests were also conducted to test how well the model fits the data. The first test used was measuring the percentage of correctly predicted values. This test is shown in Appendix Table 3.1 and 3.2. The predictive probabilities for each observation were first classified into two categories: those with values greater or equal to 0.5, and those less than 0.5. The former was defined as those observations predicted to adopt combine harvester while the latter was predicted as those who will not adopt. These observations were then cross-tabulated with their true adoption classification. The number of correctly predicted values were then divided by the total observations, which resulted to 0.8625 for the dry season and 0.8125 for the wet season. This means that the model correctly predicted

Table 33. Logistic regression analysis of the factors affecting the adoption of combine harvesters among rice farmers in Baliwag, Bulacan, dry season, 2016

VARIABLE	ODDS RATIO	AVERAGE MARGINAL EFFECTS	SE. (OR)	Z	P>Z
Age	0.969	-0.003	0.037	-0.81	0.416
Years of Schooling	0.974	-0.003	0.110	-0.23	0.816
Household Size	1.056	0.005	0.180	0.32	0.748
Non-rice Income	1.000	0.000	0.000	-1.48	0.139
Farm size	0.412	-0.086	0.225	-1.62	0.104
Attendance to seminars/on-farm trials related to combine harvesters	7.601	0.196	22.44	0.69	0.492
Tenure	0.333	-0.106	0.285	-1.28	0.199
Member of a cooperative/association	0.551	-0.058	0.520	-0.63	0.527
Perception on the benefits of combine harvesting	0.793	-0.022	0.533	-0.35	0.730
Perception on the technical characteristics of combine harvesting	1.482	0.038	0.677	0.86	0.389
Attitude Towards Labor Displacement	0.216***	-0.148	0.089	-3.70	0.000
Perception on the skill of manual harvester-laborers	0.032**	-0.332	0.046	-2.42	0.015
Chi-square (X^2)	55.43*** (p-value:v0.000)				
McFadden's Pseudo R^2	0.5237				
Log likelihood	-25.21				

***, **, and * - significant at 1%, 5%, and 10% level, respectively

Table 34. Logistic regression analysis of the factors affecting the adoption of combine harvesters among rice farmers in Baliwag, Bulacan, wet season, 2016

VARIABLE	ODDS RATIO	AVERAGE MARGINAL EFFECTS	STD. ERR. (OR)	Z	P>Z
Age	0.97	-0.005	0.029	-1.09	0.274
Years of Schooling	1.01	0.001	0.085	0.12	0.905
Household Size	1.05	0.007	0.128	0.38	0.701
Non-rice Income	1.00	0.000	0.000	-0.89	0.374
Farm size	0.60*	-0.076	0.187	-1.64	0.100
Attendance to seminars/on-farm trials related to combine harvesters	3.26	0.176	5.870	0.65	0.513
Tenure	2.03	0.105	1.438	1.00	0.317
Member of a cooperative/association	0.48	-0.109	0.363	-0.97	0.332
Perception on the benefits of combine harvesting	0.64	-0.067	0.311	-0.92	0.358
Perception on the technical characteristics of combine harvesting	1.46	0.057	0.511	1.09	0.276
Attitude Towards Labor Displacement	0.30***	-0.179	0.090	-4.03	0.000
Perception on the skill of manual harvester-laborers	0.31	-0.173	0.314	-1.16	0.247
Chi-square (X^2)	37.17*** (p-value: 0.002)				
McFadden's Pseudo R^2	0.3366				
Log likelihood	-36.64				

***, **, and * - significant at 1%, 5%, and 10% level, respectively

86.25 percent and 81.25 percent of the total observations for the dry and wet season respectively. The second test used was the Hosmer and Lemeshow's test. The test assesses whether or not the observed event rates match expected event rates in subgroups of the model population. The null hypothesis for the test was that actual and predicted event rates were similar among the ten groups. The alternate hypothesis is that the actual and predicted event rates are not the same. Thus, having a large p-value means indicates a good model fit. The Hosmer and Lemeshow chi square statistic for both seasons were equivalent to

4.57 and 4.33, with a p-value of 0.8029 and 0.8258 respectively. Because the two models have has a large p-value, it can be said that the logistic regression models fit the data well.

Multicollinearity was also tested using a correlation matrix which is shown in Appendix Table 2.1 and 2.2. A correlation of more than 0.5 or less than 0.5 between two variables may indicate a multicollinearity problem between them. However, there were no correlations of more than 0.5 for both explanatory variables in the two models. Thus, it can be concluded that the two models do not have any multicollinearity problem

Of the 12 hypothesized factors, only three factors were found significant in at least one of the two models. The only common significant factor for both seasons was the farmer's attitude towards labor displacement. During the dry season, the farmer's perception of the skill of manual harvester-laborers. During the wet season, farm size was found to significantly affect adoption. The rest of the variables were found to be insignificant.

An increase in the value of attitude towards labor displacement means having a more negative attitude towards it. Thus, having a more negative attitude towards labor displacement caused by combine harvesters negatively affects adoption. This was significant at a 1 percent level and is consistent with the hypothesis of the study. Non-adopters, it seems, significantly consider the livelihoods of their harvester-laborer in their adoption decision towards combine harvesters. This was also the top reason for farmers for not adopting combine harvesters (Table 23).

The perception on the skill of manual harvester-laborers had a significant effect towards adoption during the dry season at a 5 percent level. This means that if more farmers perceive their harvester-laborers to do a good job the last time they harvested, they will be less likely to adopt combine harvesting. The insignificance of this variable during the wet season may be due to the fact that more farmers liked to use combine harvesters during the wet season to harvest their crops quickly before the arrival of storms. Thus, even though some farmers had a positive perception towards the skill of manual harvester-laborers, the importance of harvesting crops before it gets damaged by storms supersedes it.

Farm size was significant for the wet season. However, it should be noted that for the dry season, the p-value for this variable (0.104) although not less than the 0.10, is very close to that value. This may mean that farm size, although insignificant, may have a role in affecting the adoption decision of farmers towards combine harvesters during the dry season. Surprisingly, because the odds ratios for both seasons are less than one, farm size may have a negative effect towards adoption -contrary to the hypothesis of the study. The reason for this may be that farm owners who have larger land areas, tend to not adopt combine harvesters because more harvester-laborers will be displaced if they used combine harvesting.

The rest of the variables were found to be insignificant. Among them were the socio-demographic factors (age, years of schooling, household size). This may be due to the relatively homogenous characteristics of these variables between adopters and non-adopters. The same reason can be said for the institutional variables. Tenure did not have a significant effect towards adoption. Land owners may not have an effect on the management decisions of their tenants. Thus, the decision to use combine harvesters may be primarily because of the farmer-managers' discretion. Another effect of tenure is the added payment to landowners by tenants which increased their production costs. However, because tenure was insignificant, it also seemed not to have an effect on the model.

Although the non-rice income differed between adopters and non-adopters for both seasons, they were found to be insignificant. Non-rice income, it turns out, did not have any effect on combine harvester adoption.

Farmer's attendance to seminars/on-farm trials related to combine harvesters was found to not be significant. However, it should be noted that only a tiny percentage farmers attended these seminars or on-farm trials. It may seem that there were very few seminars and on-farm trials related to combine harvesters conducted in the municipality. Thus, although it is insignificant in the adoption model, higher percentage of attendance may provide a different effect.

Surprisingly, being a member of a cooperative or association did not have a significant effect. This is because not all cooperatives in the municipality promoted the use of combine harvesters. Some even opposed its use, citing labor displacement as their primary reason.

The perception of farmers towards the benefits and technical characteristics of combine harvesting were also insignificant. Although the farmer respondents believed combine harvesting to be more beneficial in terms of timeliness, cost, and wastage (Table

20), it did not have a significant effect towards adoption. This can be seen in the very similar mean perception scores for both adopters and non-adopters. Although non-adopters generally have a more negative perception of the technical characteristics of combine harvesting, it did not have a significant effect on towards their decision to adopt combine harvesters.

To clearly understand the magnitude of the effects of the significant variables in the model, the odds ratio and the marginal effects of these variables were also computed. These are shown in Table 32. The odds ratio determines the increase in the odds of adopting combine harvesters for every unit increase in these variables. For every unit increase in the attitude towards labor displacement (OR: Dry season = 0.216, Wet season = 0.30), which was measured for every yes response in one of the four questions, the odds of adopting decreases by 78.4 percent for the dry season and 70 percent for the wet season. During the dry season, if a farmer has a positive perception on the skill of harvester-laborers (OR = 0.032), the odds for adoption decreases by 96.7 percent. For the wet season, a 1 hectare increase in farm size (OR = 0.60) will decrease the odds of adoption by 40 percent

The average marginal effects were also computed to determine the change in the probability of adoption for a change in a specific variable, holding other factors constant. For categorical variables, it determines the change in the probability of adoption from one category to another category. The only significant categorical variable was the perception on the skill of manual harvester-laborers during the dry season. Based on the marginal effects, farmers who have a positive perception of the skill of harvester-laborers are 33.2 percentage points less likely to adopt combine harvesting during the dry season.

For continuous variables, the average marginal effects measure the average instantaneous rate of change of these variables. It can be approximated that average marginal effects measure the average change in the probability of adoption for every unit change. The two significant continuous variables were the attitude towards labor displacement for both season, and farm size during the dry season. An increase in the score of Attitude Towards Labor Displacement, which has possible values of 0-4, decreases the probability of adoption by an average of 14.8 percentage points during the dry season and an average of 17.9 percentage points during the wet season. A 1 hectare increase in farm size during the wet season decreases the probability of adoption by an average of 7.6 percent percentage points.

SUMMARY AND CONCLUSION

The study was conducted to determine the factors affecting the adoption of combine harvesters among rice farmers in Baliwag, Bulacan. Specifically, the study aimed to: (1) describe the decision-making process of farmers towards the adoption of combine harvesters; (2) determine the benefits and costs of combine and non-combine harvesting; (3) identify the problems that constrain rice farmers from full adoption of combine harvesters; and (4) provide solutions and recommendations that could increase the adoption of combine harvesters.

A total of 40 combine harvester adopters and 40 non-adopters farmer respondents were randomly selected to be part of the study. Adopters were classified as those who used combine harvesters for at least one season in 2016.

The yield, price, and production value of the farmer respondents were analyzed because they affect farmers' net income and harvesting cost. For the dry season, it was found out that the differences in the yield, price, and value of production among the users of the three harvesting methods were significant. The reason why combine users had the highest yields may be due to the greater proportion of combine adopters who used hybrid seeds. Reapers had higher mean *palay* price than combine and manual. First, this may be caused by the preference of rice buyers over threshed palay using reaper and manual harvesting because of less chaff and lower moisture content when sold to them due to the inadequate winnowing equipment of combine harvesters and the prevalence of field drying after reaper and manual harvesting. The latter avoids the need to sun dry palay after being threshed. Second, this may be because reapered palay field dries more evenly and more quickly than manual. Manual harvesters had lower production value than the combine users and reaper users due to their lower yields and lower price than the other two harvesting methods. Reapers had the highest production value than combine adopters because of their higher palay prices. During the wet season, the differences in the yield, price and production value of the three harvesting methods were found to be insignificant. This was caused by the high variance in the yield because of the presence of torrential rains, storms, and strong winds during this season.

It was found out that combine harvesting used 0.60 mandays per hectare in comparison to both reaper and manual harvesting which uses 13.94 and 15.93 mandays per hectare respectively. Combine harvesting only requires 3 people to operate the combine harvester which can harvest a hectare of palay in 1-2 hours. Reapers and manual harvesting, on the other hand, requires the use of 10-20 harvester laborers per hectare and takes about 1-2 days/hectare to harvest.

The cost per hectare and cost per kilogram of combine harvesting for both the dry and the wet season were significantly lower than reaper and manual harvesting using t-test analysis. This was because of the lower percentage payment for combine compared to the other two methods. Combine harvesters generally cost 10 percent of the gross harvest. Hiring reapers cost about PhP 2,000 to 2,200 per hectare and 8.33 percent of the gross harvest for the palay gatherers. Manual harvesters cost about 11.11 percent of the total harvest. Both non-combine methods also still need threshing, which typically costs around 7 percent of the gross harvest.

The results of the partial budget analysis showed that adopting combine harvesters would increase the profit of farmers. During the dry season, switching to combine harvesters from reapers and manual increases net farm income by 17.76 percent and 21.36 percent respectively. Likewise, adopting combine harvesters during the wet season increased net farm income by 26.73 percent and 28.62 percent in the same order of mention.

The top reasons of farmers for adopting combine harvesters during the dry and wet season was that they believe combine harvesting to be less costly and have a shorter harvesting time. During the wet season, another significant reason was that more farmers prefer to harvest palay quickly to prevent it from being hit by storms. The top reason why farmers did not adopt combine harvesters for both dry and wet season was that they do not like the harvester-laborers to lose their livelihood. Other top reasons for non-adoption were: some farmers want their palay to already be field dried before threshing; andtheir traditional and personal preference for manually harvested palay.

Attitudes and perceptions analysis were conducted to determine the following: a) the benefits of combine harvesting; b) perception on the technical characteristics of combine harvesting; c) attitude towards combine harvesters in relation to labor displacement; and d) other perceptions related to combine and manual harvesting. Based on the farmers' answers, it was found out that majority of farmers for both combine and manual harvesters believed that combine harvesting was more beneficial than manual harvesting. Non-adopters had a more negative perception about the technical characteristics of combine harvesters than adopters. It was also found out that non-adopters had a more negative attitude than adopters towards combine harvesters because of labor displacement. Furthermore, more non-adopters also agreed that their harvester-laborers did their jobs well the last time they hired them. This meant that non-adopters had a more positive perception of the skill of their harvester-laborers. Eighty-five percent and 92.5 percent of both adopters and non-adopters, respectively, perceived that the price of combine harvested palay was lower than threshed palay.

Logistic regression analysis for both seasons was used to determine the factors affecting adoption. Based on the likelihood ratio chi-square test, percentage of correctly predicted values and the Hosmer and Lemeshow's test, the models were found to be significant and have a good goodness of fit. It was also found that there were no significant multicollinearity problems between the variables of the model.

For both seasons, if a farmer has a more negative attitude towards labor displacement caused by combine for both seasons harvesters (OR: Dry season = 0.216, Wet season = 0.30), adoption is negatively affected. Farmer's perception on the skill of manual harvester-laborers (OR = 0.032) was also significant in negatively affecting adoption but only during the dry season. For the wet season, an increase in farm size (OR = 0.60) was surprisingly found to decrease adoption.

In conclusion, because combine harvesters significantly decrease harvesting costs and shorten harvesting time, it is imperative that the said machine be widely promoted to rice farmers in the country. However, even though most farmers perceived combine harvesting to be more beneficial, they still did not adopt it primarily because of the laborers who will be displaced. Although they consider the economic benefits from combine harvesting, they are also wary about the welfare of the laborers. This may be due to their apprehension that the laborers will not be able to find alternative livelihoods due to lower years of formal education. Laborers, having worked for an employer for years, have an attachment with them. Some of these laborers also help farmers in the preparation, planting and crop maintenance. Consequently, once farmers adopt combine harvesters, the social cost for this is that they may get stigmatized by their laborers who refuse to work for them in the future. Hence, in promoting mechanization and other labor-saving technologies such as combine harvesters, its employment effects must also be considered.

RECOMMENDATIONS

Based on the results of the study, the following recommendations were formulated:

Promotion of alternative employment opportunities in the rural areas

For the rice industry in the Philippines to be competitive globally, productivity and profitability must be increased by using labor-saving technologies such as combine harvesters. However, this has the added consequence of labor displacement in the rural areas where is labor abundant. This was also the most significant constraint on why farmers did not adopt combine harvesters. Because of this, the development of various industries in the rural areas must be promoted by the government to generate alternative livelihoods for those displaced by combine harvesters.

Conduction seminars and on-farm trials about combine harvesters

It was shown that very few farmer respondents had experience in attending seminars or on-farm trials about combine harvesters. Despite the insignificant effect of this variable on the logistic regression models, it should be noted that only 6 out of the 80 farmer respondents attended seminars or on-farm trials. Thus, increasing the number of seminars which teach farmers on the economic benefits of combine harvesting may have a positive effect towards the farmer's decision-making process in adopting combine harvesters. Combine harvester on-farm trials can also be conducted by the government and private individuals/corporations so that farmers can get a hands-on experience with this machine.

Promoting the use of combine harvester models with better winnowing implements

Most farmer respondents in the study perceived combine harvested palay to contain more chaff than threshed palay (reaper and manual). This was also one of the reasons why they perceive combine harvested palay to have a lower price than their threshed counterparts. The cause of this was because of the inadequate winnowing implements in the combine harvester models used in the municipality. Because of this, the present models utilized in the municipality must be upgraded or replaced with models which have better winnowing implements to reduce chaff content of their harvested palay. Feedback systems can also be implemented so that manufacturers can resolve the problems encountered by the farmers and operators during the use of combine harvesters and as well as provide suggestions towards the further improvement of this machine.

Promotion of rice grain dryer services

Because combine harvesting harvests and threshes palay at the same time, the resulting grains will have a high moisture content. Because of this, farmers were either forced to sell palay directly after harvesting at a lower price, or sun-dry the grains in the roads because most of them do not have any space in which to dry them. Reaper and manually harvested palay do not have this problem because they are field dried before being threshed and sold. The practice of sun drying in the roads increases post-harvest losses and may reduce the price because of the increase in cracked grains due to vehicles trampling them. Because of this, promotion of combine harvesting services must be done with the promotion of affordable grain dryers so that combine adopters will have less post-harvest losses and be sold at higher prices because of the lower moisture content. This also eliminates the need for reaper and manual palay to be field dried. Field drying causes more damage to the palay and is not recommended by IRRI.

Recommendations for Further Research

Because of the limitations of this study, a more comprehensive study should be done to determine the factors which affect adoption of combine harvesters on a country wide level. A before and after study may also be done to determine the impacts of combine harvester adoption on rice farmers. Additionally, more robust attitudes and perception studies should be done to have a broader view of the actual attitudes and perceptions of the farmers are. Moreover, because the results of the study were insufficient in determining whether harvesting methods have an impact on price and yield, further research could be done regarding this subject matter. Finally, investment analysis for combine harvesters can also be done to determine the profitability of investing combine harvesters for rentals to other farmers. This may induce private individuals to invest in combine harvester renting services.

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APPENDICES

Appendix A. Logistic regression analysis results from Stata 13 (Dry season)

Logistic Regression Results

```
. logistic adoptor age yearsofschooling householdsize nonriceannualincome land seminarsdemo tenurepart c

Logistic regression                               Number of obs   =         80
                                                  LR chi2(12)     =      55.43
                                                  Prob > chi2     =     0.0000
Log likelihood = -25.208389                       Pseudo R2       =     0.5237

------------------------------------------------------------------------------------------------
                          adoptor | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------------------+-------------------------------------------------------------
                              age |   .9693389   .0370784    -0.81   0.416     .8993239    1.044805
                 yearsofschooling |   .9741621   .1095677    -0.23   0.816     .7814359     1.21442
                    householdsize |   1.056409   .1801194     0.32   0.748     .7563115    1.475582
              nonriceannualincome |   .9999962   2.59e-06    -1.48   0.139     .9999911    1.000001
                             land |   .4120369    .224867    -1.62   0.104      .141383    1.200812
                     seminarsdemo |   7.600508   22.44063     0.69   0.492     .0233161    2477.593
                       tenurepart |   .3328767   .2853695    -1.28   0.199     .0620244    1.786504
                             coop |   .5505242   .5200745    -0.63   0.527     .0864281    3.506692
             perceptiononbenefits |    .792582     .53324    -0.35   0.730     .2120145     2.96294
             perceptionontechchar |   1.481982   .6765709     0.86   0.389     .6056796    3.626126
attitudetowardslabordisplacement |   .2162413   .0894092    -3.70   0.000     .0961596     .486278
                              q17 |   .0321685   .0456009    -2.42   0.015     .0019989    .5176803
                            _cons |   30931.19   144394.6     2.21   0.027     3.286811    2.91e+08
------------------------------------------------------------------------------------------------
```

Average marginal effects

```
. margins, dydx(*)

Average marginal effects                          Number of obs   =         80
Model VCE    : OIM

Expression   : Pr(adoptor), predict()
dy/dx w.r.t. : age yearsofschooling householdsize nonriceannualincome land seminarsdemo tenurepart co

------------------------------------------------------------------------------------------------
                                 |            Delta-method
                                 |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------------------+--------------------------------------------------------------
                             age |  -.0030079    .003685    -0.82   0.414    -.0102303    .0042146
                yearsofschooling |  -.0025285   .0108709    -0.23   0.816     -.023835    .0187781
                   householdsize |   .0053003   .0164192     0.32   0.747    -.0268808    .0374814
             nonriceannualincome |  -3.71e-07   2.39e-07    -1.55   0.121    -8.39e-07    9.81e-08
                            land |  -.0856395   .0496211    -1.73   0.084    -.1828952    .0116161
                    seminarsdemo |   .1959024   .2830748     0.69   0.489    -.3589139    .7507188
                      tenurepart |  -.1062458   .0806379    -1.32   0.188    -.2642933    .0518016
                            coop |  -.0576522    .090659    -0.64   0.525    -.2353407    .1200362
            perceptiononbenefits |  -.0224529   .0649059    -0.35   0.729    -.1496661    .1047603
            perceptionontechchar |   .0379961   .0436333     0.87   0.384    -.0475236    .1235157
attitudetowardslabordisplacement |   -.147912   .0264188    -5.60   0.000    -.1996919    -.096132
                             q17 |  -.3319524    .118573    -2.80   0.005    -.5643512   -.0995536
------------------------------------------------------------------------------------------------
```

Hosmer-Lemeshow Test

```
. lfit, group(10) table

Logistic model for adoptor, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)
```

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.0145	0	0.0	8	8.0	8
2	0.0296	0	0.2	8	7.8	8
3	0.0632	0	0.4	8	7.6	8
4	0.1121	2	0.8	6	7.2	8
5	0.1825	1	1.1	7	6.9	8
6	0.3788	1	2.1	7	5.9	8
7	0.6882	5	3.9	3	4.1	8
8	0.8614	6	6.3	2	1.7	8
9	0.9565	7	7.3	1	0.7	8
10	0.9995	8	7.9	0	0.1	8

```
      number of observations =        80
            number of groups =        10
     Hosmer-Lemeshow chi2(8) =         4.57
                 Prob > chi2 =         0.8029
```

Percent correctly predicted

```
. estat classification

Logistic model for adoptor
```

Classified	True D	True ~D	Total
+	23	4	27
-	7	46	53
Total	30	50	80

```
Classified + if predicted Pr(D) >= .5
True D defined as adoptor != 0

Sensitivity                     Pr( +| D)   76.67%
Specificity                     Pr( -|~D)   92.00%
Positive predictive value       Pr( D| +)   85.19%
Negative predictive value       Pr(~D| -)   86.79%

False + rate for true ~D        Pr( +|~D)    8.00%
False - rate for true D         Pr( -| D)   23.33%
False + rate for classified +   Pr(~D| +)   14.81%
False - rate for classified -   Pr( D| -)   13.21%

Correctly classified                        86.25%
```

Logistic Regression Measures of Fit

```
. fitstat

Measures of Fit for logit of adoptor

Log-Lik Intercept Only:      -52.925   Log-Lik Full Model:          -25.208
D(67):                        50.417   LR(12):                       55.433
                                       Prob > LR:                     0.000
McFadden's R2:                 0.524   McFadden's Adj R2:             0.278
Maximum Likelihood R2:         0.500   Cragg & Uhler's R2:            0.681
McKelvey and Zavoina's R2:     0.816   Efron's R2:                    0.576
Variance of y*:               17.832   Variance of error:             3.290
Count R2:                      0.863   Adj Count R2:                  0.633
AIC:                           0.955   AIC*n:                        76.417
BIC:                        -243.179   BIC':                         -2.849
```

Appendix B. Logistic regression analysis results from Stata 13 (Wet season)

Logistic Regression Results

```
. logistic adoptor age yearsofschooling householdsize nonriceannualincome land seminarsdemo tenurepar

Logistic regression                             Number of obs   =         80
                                                LR chi2(12)     =      37.17
                                                Prob > chi2     =     0.0002
Log likelihood = -36.639338                     Pseudo R2       =     0.3366
```

adoptor	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	.9681062	.0286932	-1.09	0.274	.9134709	1.026009
yearsofschooling	1.01009	.0853718	0.12	0.905	.8558886	1.192073
householdsize	1.048145	.1282292	0.38	0.701	.8246809	1.332161
nonriceannualincome	.9999988	1.32e-06	-0.89	0.374	.9999962	1.000001
land	.5983442	.1870686	-1.64	0.100	.3242114	1.104267
seminarsdemo	3.255333	5.870228	0.65	0.513	.0949847	111.5674
tenurepart	2.031756	1.438296	1.00	0.317	.5073402	8.136613
coop	.4806583	.3631121	-0.97	0.332	.1093449	2.112878
perceptiononbenefits	.6391196	.3111602	-0.92	0.358	.2461321	1.659572
perceptionontechchar	1.463049	.5106797	1.09	0.276	.7381513	2.899828
attitudetowardslabordisplacement	.3008548	.0896076	-4.03	0.000	.1678156	.5393635
q17	.3115712	.3141635	-1.16	0.247	.0431791	2.248231
_cons	725.3417	2325.652	2.05	0.040	1.353157	388809.7

Average marginal effects

```
. margins, dydx(*)

Average marginal effects                          Number of obs   =         80
Model VCE    : OIM

Expression   : Pr(adoptor), predict()
dy/dx w.r.t. : age yearsofschooling householdsize nonriceannualincome land seminarsdemo tenurepart coo
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	-.0048214	.004301	-1.12	0.262	-.0132511	.0036084
yearsofschooling	.0014933	.0125639	0.12	0.905	-.0231314	.026118
householdsize	.0069943	.0181623	0.39	0.700	-.0286031	.0425917
nonriceannualincome	-1.75e-07	1.93e-07	-0.91	0.365	-5.52e-07	2.03e-07
land	-.0763941	.0439374	-1.74	0.082	-.1625099	.0097216
seminarsdemo	.1755637	.2662099	0.66	0.510	-.3461982	.6973255
tenurepart	.1054458	.1030112	1.02	0.306	-.0964525	.3073442
coop	-.1089709	.1104501	-0.99	0.324	-.3254491	.1075073
perceptiononbenefits	-.066588	.0713304	-0.93	0.351	-.2063931	.0732171
perceptionontechchar	.0566011	.0505873	1.12	0.263	-.0425482	.1557504
attitudetowardslabordisplacement	-.1786625	.0242285	-7.37	0.000	-.2261495	-.1311755
q17	-.1734564	.145954	-1.19	0.235	-.4595209	.1126081

Hosmer-Lemeshow Test

```
. lfit, group(10) table

Logistic model for adoptor, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)
```

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.0841	0	0.3	8	7.7	8
2	0.1391	1	0.8	7	7.2	8
3	0.2171	1	1.4	7	6.6	8
4	0.3052	1	2.0	7	6.0	8
5	0.3675	4	2.7	4	5.3	8
6	0.5556	4	3.8	4	4.2	8
7	0.7525	6	5.3	2	2.7	8
8	0.8169	7	6.3	1	1.7	8
9	0.8869	6	6.7	2	1.3	8
10	0.9878	7	7.6	1	0.4	8

```
      number of observations =        80
            number of groups =        10
      Hosmer-Lemeshow chi2(8) =         4.33
                  Prob > chi2 =         0.8258
```

Percent correctly predicted

```
. estat classification

Logistic model for adoptor

              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |        29             7  |         36
     -     |         8            36  |         44
-----------+--------------------------+-----------
   Total   |        37            43  |         80

Classified + if predicted Pr(D) >= .5
True D defined as adoptor != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   78.38%
Specificity                     Pr( -|~D)   83.72%
Positive predictive value       Pr( D| +)   80.56%
Negative predictive value       Pr(~D| -)   81.82%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)   16.28%
False - rate for true D         Pr( -| D)   21.62%
False + rate for classified +   Pr(~D| +)   19.44%
False - rate for classified -   Pr( D| -)   18.18%
--------------------------------------------------
Correctly classified                        81.25%
--------------------------------------------------
```

Logistic Regression Measures of Fit

```
. fitstat

Measures of Fit for logit of adoptor

Log-Lik Intercept Only:      -55.227   Log-Lik Full Model:           -36.639
D(67):                        73.279   LR(12):                        37.174
                                       Prob > LR:                      0.000
McFadden's R2:                 0.337   McFadden's Adj R2:              0.101
Maximum Likelihood R2:         0.372   Cragg & Uhler's R2:             0.496
McKelvey and Zavoina's R2:     0.589   Efron's R2:                     0.408
Variance of y*:                8.009   Variance of error:              3.290
Count R2:                      0.813   Adj Count R2:                   0.595
AIC:                           1.241   AIC*n:                         99.279
BIC:                        -220.317   BIC':                          15.410
```

Appendix Table 1. Survey Questionnaire used in the Attitudes and Perceptions Analysis

QUESTION	OO	HINDI	HINDI KO ALAM
PERCEPTION ON THE BENEFITS OF COMBINE HARVESTING			
Mas mabilis ba ang pag-aani pag ginamit ang halimaw kaysa sa gapas-tao at reaper?			
Mas nakakabawas ba ng gastos ang pag-halimaw?			
Mas marami ba ang mababawas sa ani kapag nagpa-gapas-tao at reaper kaysa sa halimaw?			
Kapag binenta na ang palay, mas mataas ang magiging kita kapag nagpa-gapas tao o reaper kaysa sa halimaw?			
PERCEPTION ON THE TECHNICAL CHARACTERISTICS OF COMBINE HARVESTING			
Lahat ng halimaw ay hindi kaya anihin ang mga dapang palay?			
Mas malinis ba ang pina-thresher kaysa sa hinalimaw?			
Lahat ba na palay na hinalimaw ay ma-ipa?			
ATTITUDE TOWARDS THE LABOR DISPLACEMENT CAUSED BY COMBINE HARVESTERS			
Bilang isang magsasaka, kailangan niyo bang pangalagaan ang kabuhayan ng mga manggagapas?			
Kung maganda at walang sakit ang mga palay, mas mainam na wag nalang gumamit ng halimaw kung mawawala ang mga kabuhayan ng mga manggagapas?			
Dapat lang gamitin ang halimaw kapag walang makukuhang manggagapas o may darating na malakas na bagyo?			
Bilang magsasaka, mas importante ba sa inyo ang pangalagaan ang hanapbuhay ng mga manggagapas kaysa sa pataasin ang sariling kita?			
Mas maganda ba na mag-halimaw nalang at bigyan nalang ng cavan o pera ang mga manga-gapas kaysa sa magpa-gapas or reaper?			
Mas mabuti ba na magpa-halimaw nalang at maghanap nalang ng alternatibong hanapbuhay ang mga manggagapas?			

Appendix Table 1. Continued…

PERCEPTION TOWARDS THE QUALITY OF MANUALLY HARVESTED PALAY			
Meron bang mga palay na natitira sa bukid kapag nagpapa-gapas?			
Mahuhusay ba ang mga manggagapas na nakuha niyo sa nakaraang anihan?			
OTHER QUESTIONS			
Mayroon ba kayong lugar na pwede niyong bantayan ang mga binibilad na palay.			
Ang mga manggagapas niyo ba ay tumutulong sa inyo sa mga gawaing pangbukid?			
Mas mababa ang presyo ng hinalimaw kaysa sa gapas?			

Appendix Table 2.1. Correlation matrix of the explanatory variables of the dry season logistic regression model, 80 farmer respondents, Baliwag, Bulacan, 2016

	AGE	SCHL	HSZE	NRI	FS	SEM	TENR	COOP	BEN	TECH	LBOR	MANL	_cons
AGE	1.00												
SCHL	0.40	1.00											
HSZE	0.03	-0.14	1.00										
NRI	-0.01	-0.06	-0.04	1.00									
FS	-0.03	-0.22	-0.03	0.14	1.00								
SEM	-0.22	-0.11	0.05	0.01	-0.32	1.00							
TENR	0.04	0.20	0.06	0.07	-0.01	-0.13	1.00						
COOP	0.06	0.11	-0.02	0.09	-0.23	-0.12	0.01	1.00					
BEN	0.16	0.09	0.04	0.18	0.14	-0.07	-0.28	0.06	1.00				
TECH	-0.30	-0.04	0.09	-0.05	0.06	0.20	-0.01	-0.30	-0.22	1.00			
LBOR	0.28	0.20	-0.15	0.24	0.28	-0.33	0.17	0.34	0.29	-0.46	1.00		
MANL	0.31	0.11	0.11	0.48	0.12	0.13	0.08	0.00	0.17	-0.20	0.15	1.00	
_cons	-0.72	-0.49	-0.18	-0.31	-0.25	0.21	-0.14	-0.12	-0.55	0.21	-0.53	-0.58	1.00

NOTE:
AGE - Age
SCHL - Years of Schooling
HSZE - Household Size
NRI - Non-rice Income
FS - Farm size
SEM - Attendance to seminars/on-farm trials related to combine harvesters
TENR - Tenure
COOP - Member of a cooperative/association
BEN - Perception on the benefits of combine harvesting
TECH - Perception on the technical characteristics of combine harvesting
LBOR - Attitude Towards Labor Displacement
MANL - Perception on the skill of manual harvester-laborers
_cons - Constant

Appendix Table 2.2. Correlation matrix of the explanatory variables of the wet season logistic regression model, 80 farmer respondents, Baliwag, Bulacan, 2016

	AGE	SCHL	HSZE	NRI	FS	SEM	TENR	COOP	BEN	TECH	LBOR	MANL	_cons
AGE	1.00												
SCHL	0.37	1.00											
HSZE	0.08	-0.09	1.00										
NRI	-0.07	-0.10	-0.05	1.00									
FS	-0.01	-0.19	-0.03	0.17	1.00								
SEM	-0.24	-0.18	0.00	0.02	-0.16	1.00							
TENR	-0.06	0.29	0.02	-0.08	-0.25	-0.07	1.00						
COOP	0.02	0.02	-0.13	0.13	-0.05	-0.25	0.00	1.00					
BEN	0.15	0.02	0.06	-0.01	0.33	-0.07	-0.29	-0.16	1.00				
TECH	-0.17	0.01	0.06	-0.05	-0.15	0.21	0.10	-0.14	-0.17	1.00			
LBOR	0.16	0.04	-0.16	0.06	0.34	-0.26	-0.18	0.27	0.26	-0.41	1.00		
MANL	0.27	0.05	0.02	0.39	0.11	0.17	-0.09	-0.01	0.10	-0.17	-0.12	1.00	
_cons	-0.76	-0.48	-0.20	-0.11	-0.27	0.21	0.01	-0.02	-0.53	0.12	-0.33	-0.43	1.00

NOTE:
AGE - Age
SCHL - Years of Schooling
HSZE - Household Size
NRI - Non-rice Income
FS - Farm size
SEM - Attendance to seminars/on-farm trials related to combine harvesters
TENR - Tenure
COOP - Member of a cooperative/association
BEN - Perception on the benefits of combine harvesting
TECH - Perception on the technical characteristics of combine harvesting
LBOR - Attitude Towards Labor Displacement
MANL - Perception on the skill of manual harvester-laborers
_cons - Constant

Appendix Table 3.1. Frequency of correctly predicted values of the dry season logistic regression adoption model, 80 farmer respondents, Baliwag, Bulacan, 2016.

PREDICTIVE PROBABILITY	TRUE		
	Adopter	Non-Adopter	Total
>=0.5	23	4	27
<0.5	7	46	53
TOTAL	30	50	80
CORRECTLY CLASSIFIED ADOPTERS	76.67%		
CORRECTLY CLASSIFIED NON-ADOPTERS	92.00%		
CORRECTLY CLASSIFIED	86.25%		

Appendix Table 3.2. Frequency of correctly predicted values of the wet season logistic regression adoption model, 80 farmer respondents, Baliwag, Bulacan, 2016.

PREDICTIVE PROBABILITY	TRUE		
	Adopter	Non-Adopter	Total
>=0.5	29	7	36
<0.5	8	36	44
TOTAL	37	43	80
CORRECTLY CLASSIFIED ADOPTERS	78.38%		
CORRECTLY CLASSIFIED NON-ADOPTERS	83.72%		
CORRECTLY CLASSIFIED	81.25%		

Table 4.1. Cost and returns analysis of rice production classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, dry season, 2016.

ITEM	CH [a]	R [b]	M[c]	F STATISTIC
	Value (PhP/ha)	Value (PhP/ha)	Value (PhP/ha)	
Returns				
Cash Returns				
Palay Sales	58,784.25	60,073.50	41,283.73	8.29**
Total cash returns	58,784.25	60,073.50	41,283.73	8.29***
Non-Cash Returns				
Home Consumption	13,895.60	13,111.54	15,086.91	0.34
Non-cash Palay Income	21,458.69	22,854.53	23,646.23	0.33
Total Non-Cash Returns	35,354.29	35,966.08	38,733.15	0.44
Total Returns	94,138.54	96,039.58	80,016.88	3.06*
Cost				
Cash Costs				
Seeds Expense	3,205.65	2,765.89	2,279.20	2.82*
Fertilizer Expense	7,900.96	7,071.26	6,732.63	1.92
Pesticide Expense	2,812.94	2,989.02	2,693.98	0.45
Hired Labor Expense	1,580.33	1,848.26	1,508.26	0.17
Fuel Expense	460.73	509.59	902.98	2.86*
Irrigation Fee	1,794.81	1,937.49	1,609.52	1.35
Land Tax	196.20	304.94	409.82	1.88
Tractor Rental	3,665.74	3,477.27	2,325.26	1.23
Reaper Rental	0.00	2,045.68	0.00	
Hauling Expense	1,952.31	1,467.20	1,487.62	5.55***
Total Cash Costs	23,569.67	24,416.60	19,949.27	5.42***
Non-cash Costs				
Harvester-Thresher's Share	8,683.22	15,286.01	14,677.18	24.55***
Landlord's Share	6,024.79	2,542.38	5,081.67	1.94
Hired Labor Share	6,750.68	5,026.15	3,887.39	2.24
Unpaid Family Labor	275.93	1,039.83	1,505.48	3.84**
Depreciation	669.40	387.79	1,008.52	1.74
Total Non-cash	22,404.01	24,282.15	26,160.23	0.9
Total Costs	45,973.68	48,698.75	46,109.50	0.33
Net Cash Farm Income	35,214.58	35,656.90	21,334.46	5.79***
Net Farm Income	48,164.86	47,340.82	33,907.38	5.48***

[a, b, c] Combine Harvester, Reaper, and Manual, respectively

Table 4.2. Cost and returns analysis of rice production classified by harvesting method, 80 farmer respondents, Baliwag, Bulacan, wet season, 2016.

ITEM	CH [a]	R [b]	M[c]	F STATISTIC
	Value (PhP /ha)	Value (PhP /ha)	Value (PhP /ha)	
Returns				
Cash Returns				
Palay Sales	43,143.07	40,607.38	33,820.40	2.46
Total cash returns	43,143.07	40,607.38	33,820.40	2.46
Non-Cash Returns				
Home Consumption	12,618.69	13,359.25	12,685.95	0.03
Non-cash Palay Income	16,220.20	17,588.41	19,082.51	1.08
Total Non-Cash Returns	28,838.90	30,947.67	31,768.45	0.41
Total Returns	71,981.97	71,555.04	65,588.85	0.71
Cost				
Cash Costs				
Seeds Expense	2,262.01	2,591.94	2,454.16	0.29
Fertilizer Expense	6,571.90	6,402.05	5,870.88	0.88
Pesticide Expense	2,857.02	2,714.32	2,684.21	0.23
Hired Labor Expense	5,923.82	5,586.46	6,016.20	0.07
Fuel Expense	373.56	629.17	898.89	4.52**
Irrigation Fee	1,435.14	1,462.50	1,434.29	0.01
Land Tax	230.94	168.75	405.00	1.99
Tractor Rental	4,325.83	2,687.50	2,003.06	4.47**
Reaper Rental	0.00	2,144.30	0.00	
Hauling Expense	1,526.47	1,185.64	1,152.76	3.42**
Total Cash Costs	25,506.68	25,572.62	22,919.45	2.69*
Non-cash Costs				
Harvester-Thresher's Share	6,646.53	11,509.91	12,119.58	24.12***
Landlord's Share	4,222.48	4,625.50	3,576.39	0.19
Hired Labor Share	5,351.19	1,453.00	3,386.54	4.25**
Unpaid Family Labor	326.43	1,361.25	1,536.84	3.98**
Depreciation	504.70	742.06	921.18	1.11
Total Non-cash	17,051.33	19,691.73	21,540.52	2.41*
Total Costs	42,558.01	45,264.35	44,459.97	0.37
Net Cash Farm Income	17,636.39	15,034.76	10,900.95	1.31
Net Farm Income	29,423.95	26,290.70	21,128.88	1.7

[a, b, c] Combine Harvester, Reaper, and Manual, respectively