

# Technical and Financial Assessment on the Adaptation of Transplanter and Combine Harvester in the Ilocos Provinces, Philippines

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**Abstract** — The technical and financial aspects on the adaptation of the 4-row transplanter (walking, riding type) and combine harvester (3-, 4-row) in the Ilocos provinces, Philippines were evaluated. The assessment was based on South Korea's experience on the utilization of the machines and conditions in the Ilocos provinces. Adaptation of the machines in the Ilocos provinces is technically feasible in terms of their adaptability to soil condition, landholdings, and capability on the operation, repair and maintenance of the machines. The use of the transplanter and combine harvester are economically viable as indicated by the benefit-cost ratios, net incomes, payback periods, and break-even points. The riding type transplanter and 3-row combine harvester are more economically viable than the walking type transplanter and 4-row combine harvester, respectively. The change from manual transplanting practice into use of the transplanter increases the net benefits. Hence, adaptation of the transplanter and combine harvester would give Ilocano farmers the opportunity to increase the productivity of their rice farms and their income. This would address problems on high production cost, scarcity of labor, and postharvest losses.

**Keywords** — Combine Harvester, Cost Analysis, Partial Budget Analysis, Technical and Financial Assessment, Transplanter.

## I. INTRODUCTION

With the increasing population and opening of the world market particularly the ASEAN Economic Community, one of the main goals of the government is to attain food sufficiency and competitiveness. To achieve this goal, farm mechanization is believed to play an important role in increasing food production, reducing production costs, minimizing losses, and preserving the quality of agricultural products. As Kang [1] had exemplified, farm mechanization mitigates labor shortage problem especially during the peak seasons and makes farm work easy.

Farm mechanization embraces the use of tools, implements and machines for agricultural land development, crop production, harvesting, storage preparation, storage, and on-farm processing [2]. In any area, it is characterized into three levels: low, fair, and high. Low mechanization level means that more than 33% of labor requirement is from manual power. Fair means animal power utilization of at least 34%. High means a minimum of 67% use of mechanical power [3].

In the Philippines, the transfer of agricultural mechanization technology has been very slow. At present, the level of mechanization in terms of available mechanical power in the farm is 1.23 hp/ha. In 1990, it was only ~0.52 hp/ha which is low compared to other countries in Asia,

especially Japan and Korea which have high levels of mechanization at ~7.00 and 4.11 hp/ha, respectively [4]. The Ilocos region is much more deprived of the mechanization despite the program, contributing only around 0.0671 hp/ha. The level of rice mechanization is only 0.044 hp/ha with the implementation of Rice Banner Program from 2011 to 2014 [5]. There is a need then to improve or enhance the level of rice mechanization, particularly in the Ilocos provinces. Hence, this study was conceived.

Ilocos Region, one of the smallest regions in the Philippines, is located in northwestern Luzon with an area of 12,974 km<sup>2</sup>. It comprises four provinces namely: Ilocos Norte, Ilocos Sur, La Union, and Pangasinan. The two northernmost provinces (Ilocos Norte and Ilocos Sur) have Type 1 climate with two distinct seasons, dry and wet. The northeastern part of Ilocos Norte, however, belongs to Type 3 climate. Temperature is cooler from December to February. Hottest months are April and May [6].

The economy in these two Ilocos provinces is anchored in the agriculture sector. Income mostly come from cultivating rice, tobacco, corn, sugarcane, and fruits; livestock raising such as pigs, chicken, goats, and carabaos. Rice is the major temporary crop.

Ilocos Norte and Sur accounted for 96,261 farms with combined area of 73,370 ha which translates to average farm size of 0.76 ha [7]. Some parts can grow rice twice a year (two cropping seasons), or even thrice in few locations. Other crops are also grown during the dry season such as corn, vegetables, garlic, onion, and tobacco, which require less water to grow.

In 2014, the rice harvest area in Ilocos Norte was 66,625 ha (85% irrigated, 15% rainfed) while 48,390 ha in Ilocos Sur. Average yield in Ilocos Norte was 4.63 mt/ha Ilocos Norte, 4.24 mt/ha in Ilocos Sur [7].

From the Php 31,928/ha spent to produce rice in irrigated areas and Php 29,379/ha in non-irrigated areas, 48% was spent on labor in 2011. Improving the efficiency of implementing activities from land preparation to harvesting, through mechanization or use of appropriate machines, may reduce the labor cost [8].

The level of agricultural mechanization in the country, which holds true to the Ilocos provinces, is still low. Mechanization in rice and corn is 1.68 hp/ha (Agricultural Mechanization Development Program 1997 as cited [4]. In rice production, only land preparation, threshing, and milling/village level processing, are intermediate to highly mechanized; all the other farm operations which include sowing or transplanting, crop care, cultivation, harvesting, cleaning, and drying are lowly mechanized [9].

Some issues and challenges on the use of agricultural machineries include: low quality of local machines, lack of local machinery manufacturer, lack of after-sales service, weak farmers' organizations, expensive cost of imported machines, and lack of political will and leadership commitment [10].

In the Ilocos provinces, many farmers are still using the conventional methods in their farming operations due to unavailability of machines or because existing machines are not appropriate for their conditions. Machines may be too big for their average farm size or too expensive for the small farmers. During crop establishment, most of the farmers manually transplant their rice seedlings. During harvest and postharvest operations, most of them use the sickle for reaping rice. For threshing and cleaning, some farmers use the beating (*hampas* method) or motorized threshers (hold-on), before winnowing. Some farmers use the axial-flow threshers wherein harvested grains are cleaned. Thus, aside from the drudgery, high cost, and scarcity of labor during peak seasons, the efficiency in rice production and quality of produce are greatly affected.

This study, therefore, aimed to conduct technical and financial assessment of adapting the transplanter and combine harvester in the Ilocos Provinces to enhance rice mechanization.

## II. OBJECTIVES

The objective of the study was to assess the technical and financial aspects of adapting the transplanter and combine harvester in the Ilocos provinces based on Korea's experience.

Specifically, it aimed to:

- 1) determine farmers' practices and problems during rice transplanting and harvesting operations;
- 2) assess the technical and financial aspects of adapting the transplanter and combine harvester; and
- 3) determine investments opportunities/potentials.

## III. METHODOLOGY

The following methodology was employed during the conduct of the study:

- 1) Determine Ilocos farmers' practices and problems as well as present situation during transplanting and harvesting operations through review of literature and interview with farmers;
- 2) Review the technical specifications, performance, and cost of the Korean transplanter and combine harvester and its adaptability in Ilocos provinces setting;
- 3) Study Korea's experience on the use of the machines; and
- 4) Assess the technical and financial aspects of adapting the Korean transplanter and combine harvester in the Ilocos provinces.

## IV. RESULTS AND DISCUSSION

### A. Baseline Information on the Practices and Problems of Farmers on Rice Transplanting and Harvesting Operations

Table 1 shows the practices and problems of farmers in the Ilocos Provinces on rice transplanting and harvesting, and possible interventions to address their needs/problems.

Table 1. Farmers' rice transplanting and harvesting practices and problems, and possible interventions in Ilocos provinces.

Operation	Farmers' Practices	Problems	Possible Interventions
Transplanting	Majority of farmers establish their rice crop through transplanting. Transplanting is done manually.	<ul style="list-style-type: none"> <li>• Limited labor during crop establishment</li> <li>• High cost of labor (P260/day)</li> <li>• Transplanting: 15-36 md/ha [11]</li> <li>• No existing transplanter machine</li> </ul>	<ul style="list-style-type: none"> <li>• Use of transplanter machine</li> </ul>
Harvesting Threshing	Use sickle for manual reaping. Done either using manual method ( <i>hampas</i> method), pedal rice thresher, and axial flow threshers (multi-purpose). Existence of threshing facilities does not mean they are actually available and accessible to potential users at the time they are needed. Harvesting is seasonal, hence, there is a demand and mobility of these machines [8].	<ul style="list-style-type: none"> <li>• Limited labor during harvest</li> <li>• High harvesting cost: 1/6 of harvest or 16.67% of harvest, i.e., 44-54 days based on harvester's share value computed at Php200 and Php/250 day [11] or P11,000</li> <li>• Around 4.29% grain losses using conventional methods with following breakdown: <ul style="list-style-type: none"> <li>• harvesting - 2.03%, piling - 0.08%</li> <li>• threshing - 2.18% (PhilMech and PhilRice 2010 as [12])</li> </ul> </li> <li>• Limited combine harvesters (only 8 units)</li> </ul>	<ul style="list-style-type: none"> <li>• Use of combine harvester</li> </ul>
Cleaning	Manually done using winnowing basket, improvised blower, or use of axial flow thresher		

*B. Technical Assessment of Adapting Korean Transplanter and Combine Harvester in the Ilocos Provinces*

The Korean transplanter and combine harvester are adaptable to the Ilocos Provinces, Philippines considering the following conditions.

1) Soil properties and condition, and climatic data

The Ilocos provinces are characterized by entisol and alfisol while South Korea is characterized by seven soil orders of which the majority is inceptisol followed by entisol (Table 2).

The soil condition of rice paddies in the Ilocos provinces and South Korea are comparable with each other in terms of texture (generally clay), depth, and water-holding capacity (not *laboy* type). The soil is usually plowed around 15 cm during land preparation.

However, the Ilocos provinces have greater annual rainfall (Ilocos Norte: 2,067 mm; Ilocos Sur: 2,552 mm) than South Korea (Southern region: 1,500 mm; Central region: 1,300 mm). Due to its climatic condition, some parts of the Ilocos provinces can plant rice twice or even thrice a year, while South Korea has only one cropping season of rice per year.

Table 2. Soil properties and climatic data for the Ilocos provinces and South Korea.

Item	Ilocos Norte	Ilocos Sur	South Korea
<b>Soil Properties</b>			
Soil Order	Characterized by entisol (paddy rice, diversified crops in the alluvial plain, fruit trees, and others) and alfisol (used for fruit trees and banana) soil orders [13].		Characterized by seven soil orders (inceptisol, entisol, ultisol, alfisol, andisol, mollisol, and histosol. However, 69.2% are inceptisol and 13.7% are entisol. [14]
<b>Climate</b>			
Type	<b>Type I:</b> Two pronounced seasons: dry from November to April and wet during the rest of the year. Maximum rain period is from June to September. The northeastern part of Ilocos Norte, however, belongs to <b>Type III</b> climate.	<b>Hernandez Type</b> (under PAGASA classification) which defines the climate as generally arid (Type E) wherein there are more dry than wet months. At most, there are only 4 ½ wet months in a year. However, southernmost portion of the province (part of Cervantes) was observed to be humid (Type B), where rain is evenly distributed throughout the year with at most 3 dry months, and eastern part of Sugpon is dry (type D) with rain not sufficiently distributed with at most 6 dry months.	<b>Four Seasons:</b> Spring, Summer, Autumn, Winter
Mean annual rainfall	171.5 mm (Tropical monsoon climate. Six severe dry months)  Annual rainfall: 2,067 mm [15]	215.0 mm August has the most rainfall while January and February have the least.  Annual rainfall: 2,552.mm [16]	Annual precipitation: 1,500 mm in southern region; 1,300 mm in central region [17]
Mean annual temperature	Max. 33.4 °C ; Min. 19.0 °C; Mean 26.8 °C	Mean 27 °C [16]	Average annual temperature: 6°C to 16°C. Hottest month is August (average temperature): 25°C Coldest month is January (average temperature): -0.7°C [17]

## 2) Size of landholdings of farmers

As in South Korea, Ilocano farmers have small landholdings, too. Ilocano farmers have 0.5–1.0 ha with average landholdings of less than a hectare (0.76 ha) while South Korea farmers have average landholdings of 1.51 ha. However, majority of South Korean farmers have less than 1.0 ha [18]. The farm area per farming household of South Korean farmers used for rice paddies is 0.844 ha (MAFRA as cited by [19]).

Large capacity transplanters and combine harvesters are being used in South Korea despite the small average landholdings of the farmers. This is due to the fact that these machines are being custom hired to other farmers or through joint utilization. For instance, one unit of the machine is used to serve 30 farmers. This scheme could also be applicable to the Ilocos provinces, where the machines could be acquired either by farmers' associations/cooperatives or individual farmers and could be used for custom hiring later.

## 3) Operators and technical capability needed

With the necessary training/demonstration on the proper operation and maintenance of the Korean transplanter and combine harvester, the Ilocano farmers can be good operators. Several machines such as tractors, threshers, brush cutters and others are operated by them. They are also known to be hardworking people like Koreans. Ilocano farmers, 57 years old average, are generally younger than South Korean farmers. As of 2013, 47.8% of Korea farm population is over 60 years old [18]. Aging of the workforce decreases productivity [17].

## 4) Availability of spare parts and repair and maintenance

Replacement parts of imported machines in the Philippines maybe hard to find. However, there are already sales agents or companies selling Korean machines in the Philippines which can provide spare parts and after-sale/repair services. Moreover, repair service centers are also available in the Ilocos provinces.

## 5) Life span and efficiency

Based on the Korea farmers' experience, the transplanter and combine harvester can have average life span of 8.5–13 years.

The use of transplanter offers more precise planting (straight planting) than when manually done (random planting), thus, the use of the rice field is maximized, which in turn result to higher productivity.

Mechanical transplanting also facilitates other operations such as weeding and application of fertilizer, herbicide, or insecticide resulting to reduced labor.

With proper and optimal spacing, yield can be increased by 25–39% over improper spacing. It also allows saving from inputs, labor, and materials. [20]

The depth of plowing in the Ilocos provinces is 10–15 cm [13] which is also comparable to South Korea (15–16 cm) [1]. The planting depth using the transplanter (2–3 cm) in Korea is the same with that of the manual transplanting in (1.5–3 cm or just good enough for the roots to be in contact with the soil [20].

The number of days to transplant rice seedlings in a hectare of land using the machine is greatly reduced, from

15–36 mandays to just 1–2 days depending on the capacity of transplanter used).

Harvesting using the combine harvester, on the other hand, would only take a day to harvest a hectare of land instead of 44–54 mandays. Harvesting losses (4.29%) using conventional method (PhilMech and PhilRice 2010 as cited by [12]) are also expected to be minimized.

## C. Financial Assessment of Adapting Korean Transplanter and Combine Harvester in the Ilocos Provinces

Comparative cost analyses of the transplanter (4-row walking type, 4-row riding type) both in Ilocos provinces in the Philippines, and South Korea conditions are shown in Tables 3 through 6. Moreover, cost analyses for the combine harvester (3-row, 4-row) are shown in Tables 7 through 8. The data gathered by [21] through an interview/survey with machine owners and farmers were used as basis in the analyses and conditions in the Ilocos provinces.

### 1) Transplanter (walking type, 4-row)

Table 3 shows the comparative cost analyses using the 4-row walking type transplanter in the Ilocos provinces, Philippines and South Korea with the assumptions used

The operating cost of using the machine depends on its annual utilization. Economic analysis on the use of the machine shows that the transplanting cost is estimated at ₱7,050.42 per hectare with annual capacity of 47.52 ha and annual utilization of 72 days at 0.66 ha/day capacity. The net income is estimated at ₱45,124.12. The capital investment of ₱350,000 can be recovered in 7.76 yr or from a transplanted area of 31.43 ha to break-even.

The transplanting cost using conventional method or manual transplanting (31 mandays at ₱260/day) is around ₱8000/ha which means a saving of ₱949.58/ha using the 4-row walking type transplanter.

The operating cost of using the machine in South Korea is estimated at ₱12,644.94 per hectare with annual capacity of 2.77 ha and utilization of 4.2 days at 0.66 ha/day capacity. The net income is estimated at ₱16,772.52. The capital investment of ₱88,400 can be recovered in 5.27 yr or from a transplanted area of 1.14 ha to break-even.

### 2) Transplanter (riding type, 4-row)

The operating cost of using the 4-row riding type transplanter in the Ilocos provinces is estimated at ₱6,123.00 per hectare with annual capacity of 126.72 ha and utilization of 72 days at 1.76 ha/day capacity (Table 4). The net income is estimated at ₱237,853.82. The capital investment of ₱1,000,000 can be recovered in 4.20 yr or from a transplanted area of 65.17 ha to break-even.

The transplanting cost using conventional method or manual transplanting (31 mandays at ₱260/day) is around ₱8,000/ha which means a saving of ₱1,877.00/ha using the 4-row riding type transplanter.

In the case of South Korea, the operating cost of using the machine is estimated at ₱19,354.06 per hectare with annual capacity of 3.49 ha and utilization of 2 days at 1.76 ha/day capacity. The net income is estimated at ₱12,403.68. The capital investment of ₱494,400 can be recovered from a transplanted area of 4.52 ha to break-even.

Tables 5 and 6 shows the partial budget analyses for conventional manual transplanting vs. use of Korean transplanters. The change in the transplanting practice from manual transplanting into using the 4-row walking type increases the net income by ₱949.58/ha (Table 5). The use of 4-row riding type increases the net income by ₱1,877.00/ha (Table 6).

### 3) Combine harvester (3-row)

Table 7 shows the comparative cost analyses using the 3-row combine harvester with the assumptions used.

For the Ilocos provinces, the assumptions include the annual utilizations and capacity of the 3-row combine harvester in a year at 0.92 ha/day operating 7 hr/day, and four months duration of harvesting period in a year. Using the machine has more advantage than the existing farmers' practice (manual reaping + threshing + winnowing). The operating cost of using the machine depends on its annual utilization. Economic analysis on the use of the machine shows that the harvesting cost is estimated at ₱4,744.30/ha with an annual capacity of 80.96 ha, for a harvesting duration of four months (two months per cropping season) in a year. The net income is estimated at ₱506,461.27. The capital investment of ₱900,000.00 can be recovered in 1.78 yr or from a harvested area of 43.08 ha to break-even.

The harvesters' share using the existing practice is 1/6 or 17% of the total harvest or around ₱11,000/ha (also the same with the prevailing rate charged by combine harvester owners in other regions) which means a saving of ₱6,255.70/ha using the 3-row combine harvester.

In South Korea condition, the operating cost of using the machine is estimated at ₱18,540.66 per hectare with an annual capacity of 4.26 ha for annual utilization of 5 days at 0.92 ha/day capacity. The net income is estimated at

₱28,756.44. The capital investment of ₱483,600.00 can be recovered for a period of 16.82 yr from a harvested area of 2.69 ha to break-even.

### 4) Combine harvester (4-row)

Table 8 shows the cost analyses using the 4-row combine harvester with the assumptions used.

For the Ilocos provinces, the assumptions include the annual utilizations and capacity of the 4-Row Combine Harvester in a year at 1.18 ha/day operating 7.05 hr/day, and four months duration of harvesting period in a year. Using the machine has more advantage than the existing farmers' practice (manual reaping + threshing + winnowing). The operating cost of using the machine depends on its annual utilization. Economic analysis on the use of the machine shows that the harvesting cost is estimated at ₱8,630.08 with an annual capacity of 103.84 ha, for a harvesting duration of four months (two months per cropping season) in a year. The net income is estimated at ₱246,092.66. The capital investment of ₱2,000,000.00 can be recovered in 8.13 yr or from a harvested area of 71.81 ha to break-even.

The harvesters' share using the existing practice is 1/6 or 17% of the total harvest or around ₱11,000/ha (also the same with the prevailing rate charged by combine harvester owners in other provinces) which means a saving of ₱2,369.92/ha using the 4-row combine harvester.

In South Korea condition, the operating cost of using the machine is estimated at ₱21,141.22 per hectare with an annual capacity of 12.14 ha for annual utilization of 11 days at 1.18 ha/day capacity. The net income is estimated at ₱53,911.05. The capital investment of ₱1,123,103.00 can be recovered for a period of 20.83 yr from a harvested area of 9.37 ha to break-even.

Table 3. Comparative cost analyses of using the Korean 4-row, walking type transplanter. Ilocos provinces, Philippines and South Korea.

Ilocos Provinces, Philippines			South Korea		
<b>Assumptions</b>			<b>Assumptions</b>		
Annual utilization (days)	48	72	Annual utilization (days)	4.2	
Annual capacity (ha); 0.66 ha/day	31.68	47.52	Annual capacity (ha); 0.66 ha/day	2.77	
Length of operation, (hr/day)	7.00	7.00	Length of operation (hr/day)	7.00	
Investment cost, IC (₱)	350,000	350,000.00	Investment cost, IC (₱)	88,400.00	
transplanter, seeding preparation equipment					
<b>Fixed Cost, FC (₱)</b>			<b>Fixed Cost, FC (₱)</b>		
Annual depreciation (₱); 10% SV, 11 yr life	28,636.36	28,636.36	Annual depreciation (₱); 10% SV, 11 yr life	7,232.73	
Interest (₱); 10% IC	35,000.00	35,000.00	Interest (₱)	-	
Repair and maintenance (₱); 5% IC	17,500.00	17,500.00	Repair and maintenance (₱)	4,550.00	
Taxes and insurance (₱); 2% IC	7,000.00	7,000.00	Taxes and insurance (₱)	-	
<b>Total TFC (₱)</b>	<b>88,136.36</b>	<b>88,136.36</b>	<b>Total TFC (₱)</b>	<b>11,782.73</b>	
<b>Variable Cost, VC (₱)</b>			<b>Variable Cost, VC (₱)</b>		
Seedling tray (300 pc/ha; ₱100/pc)	95,040.00	142,560.00	Seedling tray (₱)	-	
Fuel (₱); 2.14 li/hr; ₱28/li	20,133.12	30,199.68	Fuel (₱); 2.14/li; ₱56.94/li	3,582.44	
Oil (₱); 0.31 li/hr; ₱140/li	14,582.40	21,873.60	Oil (₱); 0.31 li/hr; ₱360.03/li	3,281.31	
Labor Cost (₱); Seeding: 1 person/day= 250 trays; ₱260/day; 300 pc/ha	9,884.16	14,826.24	Labor Cost (₱); Seeding	-	
Labor Cost (₱); 2 machine operators; ₱520/day	24,960.00	37,440.00	Wage/year (₱); ₱3900/day	16,380.00	

<b>Total VC (₱)</b>	<b>164,599.68</b>	<b>246,899.52</b>	<b>Total VC (₱)</b>	<b>23,243.75</b>
<b>Total Cost (₱); FC+VC</b>	<b>252,736.04</b>	<b>335,035.88</b>	<b>Total Cost (₱); FC+VC</b>	<b>35,026.48</b>
<b>Operating Cost of Transplanting (₱/ha)</b>	<b>7,997.78</b>	<b>7,050.42</b>	<b>Operating Cost of Transplanting (₱/ha)</b>	<b>12,644.94</b>
<b>Transplanting Benefit (₱/ha)</b>	<b>8,000.00</b>	<b>8,000.00</b>	<b>Transplanting Benefit (₱/ha)</b>	<b>18,700.00</b>
<b>Total Benefit (₱)</b>	<b>253,440.00</b>	<b>380,160.00</b>	<b>Total Benefit (₱)</b>	<b>51,799.00</b>
<b>Net Income (₱)</b>	<b>703.96</b>	<b>45,124.12</b>	<b>Net Income (₱)</b>	<b>16,772.52</b>
<b>Benefit-Cost Ratio</b>	<b>1.00</b>	<b>1.13</b>	<b>Benefit-Cost Ratio</b>	<b>1.48</b>
<b>Payback period (yr)</b>	<b>497.19</b>	<b>7.76</b>	<b>Payback period (yr)</b>	<b>5.27</b>
<b>Break-even Point (ha)</b>	<b>31.43</b>	<b>31.43</b>	<b>Break-even Point (ha)</b>	<b>1.14</b>
<b>Savings vs. manual (₱)</b> (Manual: 31days, P260/day)	<b>0.00</b>	<b>949.58</b>	<b>Savings if machine is owned (₱)</b>	<b>6,055.06</b>

\*P1=₱0.039

Table 4. Comparative cost analyses of using the Korean 4-row, riding type transplanter. Ilocos provinces, Philippines, and South Korea.

<b>Ilocos Provinces</b>			<b>South Korea</b>	
<b>Assumptions</b>			<b>Assumptions</b>	
Annual utilization (days)	48	72	Annual utilization (days)	1.98
Annual capacity (ha); 1.76 ha/day	84.48	126.72	Annual capacity (ha); 1.76 ha/day	3.49
Length of operation (hr/day)	9.00	9.00	Length of operation (hr/day)	9.00
Investment cost, IC (₱); transplanter, seeding preparation equipment	1,000,000.00	1,000,000.00	Investment cost, IC (₱)	494,000.00
<b>Fixed Cost, FC (₱)</b>			<b>Fixed Cost, FC (₱)</b>	
Annual depreciation (₱); 10% SV, 11 yrs life	81,818.18	81,818.18	Annual depreciation (₱); 10% SV, 11 yrs life	44,460.00
Interest (₱); 10% IC	100,000.00	100,000.00	Interest (₱)	
Repair and maintenance (₱); 5% IC	50,000.00	50,000.00	Repair and maintenance (₱)	10,010.00
Taxes and insurance (₱); 2% IC	20,000.00	20,000.00	Taxes and insurance (₱)	
<b>Total FC (₱)</b>	<b>251,818.18</b>	<b>251,818.18</b>	<b>Total FC (₱)</b>	<b>54,470.00</b>
<b>Variable Cost, VC (₱)</b>			<b>Variable Cost, VC (₱)</b>	
Seedling tray (₱); 300 pc/ha; ₱100/pc	253,440.00	380,160.00	Seedling tray (₱)	-
Fuel (₱); 3 li/hr; ₱28/li	25,885.44	38,828.16	Fuel (₱); 3.0/li; P56.94/li	3,044.01
Oil (₱); 0.36 li/hr; ₱140/li	18,748.80	28,123.20	Oil (₱); 0.36 li/hr; P360.03/li	2,309.66
Labor Cost (₱); Seeding: 1 person/day= 250 trays; 300 trays/ha; ₱260/day	26,357.76	39,536.64	Labor Cost (₱); Seeding	-
Labor Cost (₱); 2 machine operators; ₱520/day	24,960.00	37,440.00	Wage/year (₱); ₱3900/day	7,722.00
<b>Total VC (₱)</b>	<b>349,392.00</b>	<b>524,088.00</b>	<b>Total VC (₱)</b>	<b>13,075.68</b>
<b>Total Cost (₱); FC+VC</b>	<b>601,210.18</b>	<b>775,906.18</b>	<b>Total Cost (₱); FC+VC</b>	<b>67,545.68</b>
<b>Operating Cost of Transplanting (₱/ha)</b>	<b>7,116.60</b>	<b>6,123.00</b>	<b>Operating Cost of Transplanting (₱/ha)</b>	<b>19354.06214</b>
<b>Transplanting Benefit (₱/ha)</b>	<b>8,000.00</b>	<b>8,000.00</b>	<b>Transplanting Benefit (₱/ha)</b>	<b>15800</b>
<b>Total Benefit (₱)</b>	<b>675,840.00</b>	<b>1,013,760.00</b>	<b>Total Benefit (₱)</b>	<b>55,142.00</b>
<b>Net Income (₱)</b>	<b>74,629.82</b>	<b>237,853.82</b>	<b>Net Income (₱)</b>	<b>(12,403.68)</b>
<b>Benefit-Cost Ratio</b>	<b>1.12</b>	<b>1.31</b>	<b>Benefit-Cost Ratio</b>	<b>0.82</b>
<b>Payback period (yr)</b>	<b>13.40</b>	<b>4.20</b>	<b>Payback period (yr)</b>	<b>(39.83)</b>
<b>Break-even Point (ha)</b>	<b>65.17</b>	<b>65.17</b>	<b>Break-even Point (ha)</b>	<b>4.52</b>
<b>Savings vs. Manual</b> (Manual: 31days, ₱260/day)	<b>883.40</b>	<b>1,877.00</b>	<b>Savings if machine is owned</b>	<b>(3,554.06)</b>

\*P1=₱0.039

**Table 5. Partial budget analysis for conventional manual transplanting vs. use of Korean 4-row, walking type transplanter.**

<b>Benefits (₱)</b>		<b>Cost (₱)</b>	
<b>Added returns (₱)</b>	0	<b>Reduced returns (₱)</b>	0
<b>Reduced Cost (₱)</b>		<b>Added cost (₱)</b>	
<b>Labor cost</b>	<b>8,000</b>	<b>Labor cost</b>	<b>7,050.42</b>
Manual transplanting	8,000	Operating cost (at 72 ha/yr utilization)	7,050.42
<b>Sub-total reduced cost (₱)</b>	<b>8,000</b>	<b>Sub-total reduced cost (₱)</b>	<b>7,050.42</b>
<b>Total (₱)</b>	<b>8,000</b>	<b>Total (₱)</b>	<b>7,050.42</b>
<b>Net benefits (₱)</b>	<b>949.58</b>		

\*₱1=₱0.039

**Table 6. Partial budget analysis for conventional manual transplanting vs. use of Korean 4-row, riding type transplanter.**

<b>Benefits (₱)</b>		<b>Cost (₱)</b>	
<b>Added returns (₱)</b>	0	<b>Reduced returns (₱)</b>	0
<b>Reduced Cost (₱)</b>		<b>Added cost (₱)</b>	
<b>Labor cost (₱)</b>	<b>8,000</b>	<b>Labor cost (₱)</b>	<b>6,123</b>
Manual transplanting	8,000	Operating cost (at 74 ha/yr utilization)	6,123
<b>Sub-total reduced cost (₱)</b>	<b>8,000</b>	<b>Sub-total reduced cost (₱)</b>	<b>6,123</b>
<b>Total (₱)</b>	<b>8,000</b>	<b>Total (₱)</b>	<b>6,123</b>
<b>Net benefits (₱)</b>	<b>1,877</b>		

\*₱1=₱0.039

**Table 7. Comparative cost analyses of using the Korean 3-Row Combine Harvester. Ilocos provinces, Philippines, and South Korea.**

<b>Ilocos Provinces</b>		<b>South Korea</b>	
<b>Assumptions</b>		<b>Assumptions</b>	
Annual utilization (days)	44	88	4.61
Annual capacity (ha); 0.92 ha/day	40.48	80.96	4.26
Length of operation (hr/day)	7.00	7.00	7.00
Investment cost (₱)	900,000.00	900,000.00	483,600.00
<b>Fixed Cost, FC (₱)</b>		<b>Fixed Cost, FC (₱)</b>	
Annual depreciation (₱); 10% SV, 13 yrs life	62,307.69	62,307.69	33,480.00
Interest (₱); 10% IC	90,000.00	90,000.00	-
Repair and maintenance (₱); 5% IC	45,000.00	45,000.00	15,600.00
Taxes and insurance (₱); 2% IC	18,000.00	18,000.00	-
<b>Total FC (₱)</b>	<b>215,307.69</b>	<b>215,307.69</b>	<b>49,080.00</b>
<b>Variable Cost, VC (₱)</b>		<b>Variable Cost, VC (₱)</b>	
Fuel (₱); 3.58 li/hr; ₱28/li	30,873.92	61,747.84	6582
Oil (₱); 0.18 li/hr; ₱140/li	7,761.60	15,523.20	2106
Wage (₱/yr); Wage/day=₱1040; 4 operators	45,760.00	91,520.00	21,215.22
<b>Total VC (₱)</b>	<b>84,395.5</b>	<b>168,791.0</b>	<b>29,903.2</b>
Total VC/ha (₱)	2,084.9	2,084.9	7,019.5
<b>Total Cost (FC+VC)</b>	<b>299,703.21</b>	<b>384,098.73</b>	<b>78,983.22</b>
<b>Operating Cost of Harvesting (₱/ha)</b>	<b>7,403.74</b>	<b>4,744.30</b>	<b>18,540.66</b>
<b>Harvesting Benefit (₱/ha)</b>	<b>11,000.00</b>	<b>11,000.00</b>	<b>25,291.00</b>
<b>Total Benefit (₱/yr)</b>	<b>445,280.00</b>	<b>890,560.00</b>	<b>107,739.66</b>
<b>Net Income (₱)</b>	<b>145,576.79</b>	<b>506,461.27</b>	<b>28,756.44</b>
<b>Benefit-Cost Ratio</b>	<b>1.49</b>	<b>2.32</b>	<b>1.36</b>
<b>Payback period (yr)</b>	<b>6.18</b>	<b>1.78</b>	<b>16.82</b>
<b>Break-even Point (ha)</b>	<b>33.62</b>	<b>43.08</b>	<b>2.69</b>
<b>Savings from using machine vs. existing practice (₱)</b>	<b>3,596.26</b>	<b>6,255.70</b>	<b>Savings if machine is owned (₱) 6,750.34</b>

\*₱1=₱0.039

Table 8. Comparative cost analyses of using the Korean 4-Row Combine Harvester. Ilocos provinces, Philippines, and South Korea.

<b>Ilocos Provinces</b>			<b>South Korea</b>	
<b>Assumptions</b>			<b>Assumptions</b>	
Annual utilization (days)	44	88	Annual utilization (days)	10.28
Annual capacity (ha); 1.18 ha/day	51.92	103.84	Annual capacity (ha); 1.18 ha/day	12.14
Length of operation, (hr/day)	7.05	7.05	Length of operation (hr/day)	7.05
Investment cost, IC (₱)	2,000,000.00	2,000,000.00	Investment cost, IC (₱)	1,123,103.00
<b>Fixed Cost (FC)</b>			<b>Fixed Cost (FC)</b>	
Annual depreciation (₱); 10% SV, 8.5 yrs life	211,764.71	211,764.71	Annual depreciation (₱); 10% SV, 8.5 yrs life	118,916.79
Interest (₱); 10% IC	200,000.00	200,000.00	Interest (₱)	-
Repair and maintenance (₱); 5% IC	100,000.00	100,000.00	Repair and maintenance (₱)	63,073.00
Taxes and insurance (₱); 2% IC	40,000.00	40,000.00	Taxes and insurance (₱)	-
<b>Total FC (₱)</b>	<b>551,764.71</b>	<b>551,764.71</b>	<b>Total FC (₱)</b>	<b>181,989.79</b>
<b>Variable Cost, VC (₱)</b>			<b>Variable Cost, VC (₱)</b>	
Fuel (₱); 3.58/li; ₱28/li	95,541.60	191,083.20	Fuel (₱); 3.58/li; ₱56.94/li	22,332.00
Oil (₱); 0.18 li/hr; ₱140/li	30,889.72	61,779.43	Oil (₱); 0.18 li/hr; ₱360.03/li	7,224.00
Wage (₱/yr); ₱1040/day	45,760.00	91,520.00	Wage (₱/yr)	45,108.64
<b>Total VC (₱)</b>	<b>172,191.32</b>	<b>344,382.63</b>	<b>Total VC (₱)</b>	<b>74,664.64</b>
<b>Total VC/ha (₱)</b>	<b>3,316.47</b>	<b>3,316.47</b>	<b>Total VC/ha (₱)</b>	<b>6,150.30</b>
<b>Total Cost (₱); FC+VC</b>	<b>723,956.02</b>	<b>896,147.34</b>	<b>Total Cost (₱); FC+VC</b>	<b>256,654.43</b>
<b>Operating Cost of Harvesting (₱/ha)</b>	<b>13,943.68</b>	<b>8,630.08</b>	<b>Operating Cost of Harvesting (₱/ha)</b>	<b>21,141.22</b>
Harvesting Benefit (₱/ha)	11,000.00	11,000.00	Harvesting Benefit (₱/ha)	25,582.00
<b>Total Benefit (₱/yr)</b>	<b>571,120.00</b>	<b>1,142,240.00</b>	<b>Total Benefit (₱/yr)</b>	<b>310,565.48</b>
<b>Net Income (₱)</b>	<b>(152,836.02)</b>	<b>246,092.66</b>	<b>Net Income</b>	<b>53,911.05</b>
<b>Benefit-Cost Ratio</b>	<b>0.79</b>	<b>1.27</b>	<b>Benefit-Cost Ratio</b>	<b>1.21</b>
<b>Payback period (yr)</b>	<b>(13.09)</b>	<b>8.13</b>	<b>Payback period (yr)</b>	<b>20.83</b>
<b>Break-even Point</b>	<b>71.81</b>	<b>71.81</b>	<b>Break-even Point</b>	<b>9.37</b>
<b>Savings from using machine vs. existing practice</b>	<b>(2,943.68)</b>	<b>2,369.92</b>	<b>Savings if machine is owned</b>	<b>4,440.78</b>

## V. CONCLUSION

The adaptations of the 4-row Korean transplanter (walking type, riding type), and combine harvester (3-row, 4-row), in the Ilocos provinces in the Philippines are economically and technically feasible. These would help the Ilocano farmers to increase the productivity of their rice farms and their income rather than using the conventional methods of manual transplanting and harvesting.

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