Dissemination of portable combining machine as appropriate technological adoption for corn farming in sloping region
Study case: Gorontalo Province, Indonesia

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Abstract. Corn is vital crop cultivation in Gorontalo Province and becomes major export commodity from the agricultural sector. Most of corn farms are located in hilly and mountainous area known as sloping agriculture. The main aim of this study was to analyze the advantages of portable combine machine, peeling-thresher corn as appropriate technology, to support sloping agriculture, reduce cost production, and generate farmers income. This research was conducted in Tutuwoto village that involves two farmers group association (POKTAN) namely POKTAN Dusun Beringin and POKTAN Dusun Puncak. The POKTAN members stated that labour budget is the most expensive for corn production in their region. Dissemination of peeling-thresher machine is proven shorten of harvest and post-harvest steps in the current pattern. Results revealed that the technological input decreased 34.50% operational cost of harvest and post-harvest from Rp8,520,000 to Rp2,940,000. Furthermore, its application improved the farmers net profit 51.67% ha⁻¹ and 85.01% ha⁻¹ for own and loan capital respectively, in one growing season about 4 month. It is concluded that the proper equipment implemented in hilly farming reduces cost production and its implication redoubles revenue of the corn farmers.

1. Introduction
Gorontalo is one of the provincial centers for national corn production to food and feed consumption in which contributes 4% to corn production of total or seventh largest in national scale [1]. The farming area reaches 140,460 ha or 3.7% of total area in Indonesia [2] and with average yield 8.4 tons ha⁻¹ dry grain, potentially total corn produced is about 1.18 million tons for one seasonal planting or 2.36 million tons per year. The occupation majority of people is farmer where corn is the second largest plant cultivation after rice. Furthermore, corn is the province’s primary export commodity to The Philippines and Malaysia from agricultural sector that reach 135,000 ton or 21% of total production [3] with average annual production about 643,512 tons [4; 5]. As a result, corn farming for this province is extremely promising for both local and international market.

In Gorontalo, corn farming can be classified as sloping agriculture that utilized rainfed condition as irrigation. In fact, corn cultivation is performed in upland, mountain and hilly area (slope > 15%) due to lowland or plain area with surpass water focusing to rice. Because the crop water requirements depends on rainfed condition and effort to provide artificial irrigation system so problematic and challenging, the cultivation now is only undertaken one or two times per year. Although, several
technique have been proposed in other regions to overcome this problem [6], but is still not realize yet in this region.

Scarcity of proper instruments become fundamental challenge for corn farmers specifically for sloping agriculture in marginal area and difficult topography [3]. Consequently, cost production is most costly since it require more manpower. In addition, its implication certainly influence income generation from the farmer. By the various limitations, suitable instruments and machine are believed key to overcome farming obstacles on those area [7; 8; 9].

Previous study, [10] Maikhuri et al. (2010) confirmed that adoption of specific-technological input is crucial for marginal area and extreme topography to hike economic local society and livelihood security. In other hand, economic feasibility through the technology input is needed to identify sustainability and profitability farming in rural area dealing with sloping agriculture in mountain and hilly region [11]. In addition, [12] Sianipar et al. (2013) stated that fit technology have linking function to empowering poor community in rural areas.

Therefore, the objectives of this research were to (1) analyze impact of portable combining machine input, peeling-thresher corn as appropriate technology on changing harvest and post-harvest pattern, to (2) identify the comparison of farm employee cost between peeling-thresher machine and thresher machine (single function without peeling) on harvest and post-harvest corn management in sloping agriculture, and to (3) identify net profit of the farmer dissemination of appropriate technology for mountain and hilly area.

2. Materials and methods
The study was carried out in the Sub-district of Tutuwoto Village, Kwandang, North Gorontalo District, Gorontalo Province. Government statistics authority noted that North Gorontalo produces 55,306 tons per year corn dry grain with the farming area 20,840 hectares [13]. In this study, the cultivation area is situated in marginal field, then the topography of the rising and falling slope such as mountain and hilly area that utilizes rainfed irrigation. This study case involves the participation of two POKTAN (farmer groups association) namely POKTAN Dusun Puncak and POKTAN Dusun Beringin, with 20 and 17 members of each.

Production cost was calculated for one hectare area in one growing season from July to October 2020 with exchange rate, Rupiah (Rp) (1$ = Rp14.26 on July 1, 2020). Existed technology in Tutuwoto village just only thresher machine (single function) and almost of the farmer still use middlemen’s machine. Thus, portable combine machine (dual function), peeling-thresher corn machine, as appropriate technology is used made by Romi Djafar (unpublished data).

![Hilly area for corn farming in Tutuwoto village.](image1)

**Figure 1.** Hilly area for corn farming in Tutuwoto village.
2.1. Production cost
Total cost of producing corn in the sloping region for one seasonal growing is at Rp17,461,500 per hectare that consisted of raw material, hired labour, and unexpected expenses (5% of the total) as recorded in Table 1. Raw material cost comprise pre-harvest (seed, fertilizer, herbicide, pesticide, and gauco) and post-harvest (sack bag), Rp4,110,000 and Rp420,000, respectively. Corn seed which is not subsidized from governance is the most expensive raw material. In other hand, Table 1 showed that corn producers of members of POKTAN Dusun Puncak and POKTAN Dusun Beringin spent the highest cost for paying farm workers Rp4,000,000 (pre-harvest) and Rp8,100,000 (post-harvest). The cost of seasonal-wage labour was included in all the farming practices; i.e. soil tillage or ploughing, weeding and cutting grass, planting, fertilizing, pest control, peeling, threshing, and transportation.

Corn farmers spend Rp4,000,000 in cash for farm employees (pre-harvest) include planting the seed, cow ploughing, cutting the grass, fertilizing, and spraying. Its salary of hired employee is subtle similar with raw materials expenditure. In other side, among the expenses paid in cash by the farmer, hired labour for post-harvest accounted about 46.39% of total cost production or twice more than pre-harvest salary. Thus, three quarter of operational cost incurred by Tutuwoto corn farmer is spent for labour fee at Rp12,100,000 as implied in Table 1.

Highest labour cost is for peeling process that amount reaches Rp2,880,000. After peeling process, the second highest cost is spent for transportation. Cost of transportation is substantial for agriculture in sloping region. Table 1 pointed out that transportation is undertaken three times in post-harvest activities which the cost totally reaches Rp2,520,000 as recorded in item 17, item 20, and item 21.

There are two capital system for corn producer such as own capital and loan capital. The different system will influence starter cost production. In current situation, most of group members both POKTAN Dusun Puncak and POKTAN Dusun Beringin have relied on loan capital to begin farming activities.

Loan capital user about 90% for each farmer groups, 18 members of POKTAN Dusun Puncak and 15 members of others. The loan from middlemen is utilized by the farmer as initial expenses (pre-harvest need). Habitually, lending money was returned after the crop is sold or 4.5 month with rate interest 7% (Rp567,700 per month). Consequently, loan capital user spent Rp10,664,650 for pre-harvest expenses, 23.95% higher than the recorded Rp8,110,000 of own capital farmers. As a result, whole budget expand from Rp17,461,500 to Rp20,015,500 as demonstrated in Table 2. Inevitably, role of the middlemen is debatable [14].

| Item | Pre-harvest | Units | Rp/units | Total cost, Rp |
|------|-------------|-------|----------|---------------|
| **A. Raw Material** | | | | |
| 1 | Herbicide *Raxxx* (gallon) | 1 | 340,000 | 340,000 |
| 2 | Herbicide *Axxxx DMA* | 1 | 80,000 | 80,000 |
| 3 | Herbicide *Cornexxx* | 1 | 310,000 | 310,000 |
| 4 | Pesticide *Axxxx* | 1 | 180,000 | 180,000 |
| 5 | Seed (Bisi 18) | 1 | 1,700,000 | 1,700,000 |
| 6 | Gauco-mixture of seed | 1 | 80,000 | 80,000 |
| 7 | Fertilizer (sack/50 kg) | 8 | 125,000 | 1,000,000 |
| 8 | Fertilizer (sack/50 kg) | 4 | 105,000 | 420,000 |
| **Subtotal A** | | | | **4,110,000** |

| Item | Labour | Units | Rp/units | Total cost, Rp |
|------|--------|-------|----------|---------------|
| 9 | Cutting grass (4 person/ day) | 4 | 150,000 | 600,000 |
| 10 | Spraying –herbicide (2 person/day) | 2 | 175,000 | 350,000 |
| 11 | Cow ploughing (4 person/day) | 4 | 300,000 | 1,200,000 |
12 Planting the seed (25 person/day) | 25 | 50,000 | 1,250,000
13 Fertilizing (12 sack) (2 person/day) | 12 | 50,000 | 600,000

Subtotal B | 4,000,000

Total Pre-harvest (Subtotal A+ Subtotal B) | 8,110,000

| Item | Harvest and Post-Harvest | Units | Rp/units | Total Cost, Rp |
|------|--------------------------|-------|----------|---------------|
| C.  | Raw Material             |       |          |               |
| 14   | Sack (piece)             | 140   | 3,000    | 420,000       |

Subtotal C | 420,000

D. Labour and Transportation
15 Cutting the stalk (3 person/4 days) | 12 | 100,000 | 1,200,000
16 Peeling (7 person/7 days = 288 sack) | 288 | 10,000 | 2,880,000
17 Distribution to thresher location | 288 | 4,000 | 1,120,000
18 Thresher process (The kernel= 140 sack) | 140 | 5,000 | 700,000
19 Man of thresher (10 person/ day) | 10 | 80,000 | 800,000
20 Transportation to asphalt road (140 sack) | 140 | 5,000 | 700,000
21 Transportation to warehouse (buyer) | 140 | 5,000 | 700,000

Subtotal D | 8,100,000

Total Harvest and Post-harvest (Subtotal C +Subtotal D) | 8,520,000

| Item | E. Unforseen Cost |       |          |               |
|------|-------------------|-------|----------|---------------|
| 22   | 5% unexpected expenses | 0.05 | 16,630,000 | 831,500       |

Unforseen cost (subtotal E) | 831,500

Total Pre-Harvest | 8,110,000
Total Harvest and Post-Harvest | 8,520,000
Total unforseen cost | 831,500

Total of Production Cost | 17,461,500

Table 2. Total cost of corn production for capital loan user (7% interest month−1)

| Item | Detail | Units | Rp/units | Total Cost, Rp |
|------|--------|-------|----------|---------------|
| 1    | Pre-harvest |       |          | 8,110,000     |
| 2    | Harvest and post-harvest |       |          | 8,520,000     |
| 3    | 5% unexpected expenses |       |          | 831,000       |
| 4    | Interest of pre-harvest (4.5 month) | 4.5 | 567,700 | 2,554,650     |

Total of production cost | 20,015,500

2.2. Corn farming activities
Agricultural practices in slope area will be more difficult than on flat area due to topographical factors; therefore, specific information about the practices in this area is vital. Table 3 illustrated that presence of labour is important to support every work in corn farming, from land preparation until post-harvest management.
Table 3. Existing condition of cultivating corn from initial to sell.

| No | Pre-Harvest          | Labour (day⁻¹) | Harvest and Post-Harvest | Labour (day⁻¹) | Number of sacks |
|----|----------------------|----------------|--------------------------|----------------|-----------------|
| 1  | Cutting grass        | 4              | Cutting stalk            | 12             | -               |
| 2  | Spraying weed        | 1              | Peeling process          | 49             | -               |
| 3  | Ploughing            | 4              | Transport 1              | -              | 288*            |
| 4  | Planting corn seed   | 25             | Threshing step           | 10             | -               |
| 5  | Spraying weed+pest   | 1              | Transport 2              | -              | 140*            |
| 6  | Fertilizing          | 2              | Transport 3              | -              | 140*            |

Note: *labour fee for transportation are determined by the number of sacks not day

Corn farmers require hired 37 labour day-1 to all pre-harvest task where planting the seed with highest employee with 25 labour day-1. In Other side, farmers need most labour for peeling process (49 labour day-1). Except for transportation, amount of salary for all activities is counted according to the day with specific activities [16]. Transportation cost is decided by amount of sack or bag. For a successful season, corn yields in one hectare typically reach 288 sack and 140 sack for corncob and kernels, respectively.

Figure 2. Activities of corn farming before peeling-thresher machine input.

There are three steps of transportation process in one seasonal growing in study case location, Tutuwoto hilly region. After peeling process, farm workers by motorcycle bring corncob (cob+kernel) from field to thresher location (Transport 1). Next, the worker in transport 2 convey corn kernels from
thresher location to a car-accessible road. After thresher corncob to corn kernels (grain), several farmers particularly own capital user choice to carry out drying process to reach optimum moisture content that affect selling price. Lastly, transport 3 distributes the dry grain yield from the road to warehouse.

Pre-harvest activities for corn production in sloping agriculture is started preparing land, planting seed, and nurturing plant. Initial preparation consists of three activities namely cutting grass, spraying weed, and ploughing (Figure 2). In this sloping region, farmers plough their land using cow before the land is ready to planting. Next, nurturing plant is with spraying weed, pest control and fertilizing schedule. Moreover, harvest and post-harvest practices comprise six steps that is dominated by transportation which occurs three times during a growing season. Cutting the corn stalk, the peeling process, and the threshing process are some of the other activities. The peeling process, which occurs prior to the mechanization, necessitates the most labour, and it is also the most expensive expenditure on corn production for the POKTAN’s members in Tutuwoto village.

![Images](image_url)  

**Figure 3.** Several activities of the post-harvesting corn in Tutuwoto Village.
2.3. Corn price
Corn price data were collected from wholesaler (PT Gorontalo Pangan Lestari and UD Krisna). The price depends on targeted buyer and moisture content (MC) of corn kernels. Pre-harvest cost source decides targeted buyer. The farmer that use own capital receives higher price due to selling directly to wholesaler, while the farmers who borrow money must sell their kernels via middlemen as borrower. Based on MC, price list of the kernels is only divided into two categories; (i) 13-15 percent and (ii) 25-30 percent. Price gap between those moisture categories are Rp500. If the moisture is between 16-24 percent, the price is determined by buyer with price margin less than Rp500 (from Rp50 to Rp 450).

Table 4. Comparative price corn based on buyer and moisture content (MC).

| No | Buyer                | Price          | MC (%) | Fund       |
|----|----------------------|----------------|--------|------------|
| 1  | Authorized buyer / wholesaler | Rp3,200/kg, Rp2,700/kg | 13-15, 25-30 | Own capital |
| 2  | Middlemen/ Collectors   | Rp3,000/kg, Rp2,500/kg | 13-15, 25-30 | Loan capital |

Source: (1) PT Gorontalo Pangan Lestari and (2) UD Krisna (April, 2020)

Corn kernels (yields) are sold to authorized buyer at Rp3,200 kg⁻¹ (MC 13-15%) and Rp2,700 kg⁻¹ (MC 25-30%). In other side, middlemen or collectors buy the kernels lower Rp200 for each moisture content categories. As an agreement between middlemen and loan capital users, middlemen assess corn prices lower than authorized buyer (standard price of government). In this case, besides pre-harvest cost, the middlemen also influence corn price.

2.4. Profit
As primary export commodity in agricultural sector, there is no problem about corn yield market. Instead, net profit determine encouragement of farmer to cultivate their field in long distance. Estimate of profit is important to know the sustainability corn farming. Table 5 presented that a significance different in income between own capital user and loan capital user.

Table 5. Farmers’s profit to one hectare in growing season (4 month) to 25-30% MC.

| No | Buyer                  | Yield (kg) | Price (Rp) | Gross sales (Rp) | Total Cost (Rp) | Net Profit (Rp) | Fund       |
|----|------------------------|------------|------------|------------------|-----------------|-----------------|------------|
| 1  | Authorized buyer       | 8,400      | 2,700      | 22,680,000       | 17,461,000      | 5,219,000       | Own        |
| 2  | Middlemen/ Collectors  | 8,400      | 2,500      | 21,000,000       | 20,015,500      | 984,000         | Loan       |

Normally, On POKTAN Dusun Puncak and Beringin, 1 hectare area potentially produce 8,400 kg (8.4 ton kernel) –harvest is successful category-. The POKTAN farmers receive Rp22,680,000 (own capital) and Rp21,000,000 (loan capital user) from selling the dry grain yield as gross sales. Net revenue for own capital and the loan user are Rp5,219,000 and Rp984,000 per hectare for once seasonal planting as shown in Table 5. Thus, benefit obtaining by the loan user is very low; where, its revenue toward to break even point.

3. Results and discussion

3.1. Changing harvesting pattern
Technological intervention contributed to shortcut old harvest and post-harvesting pattern. In the old pattern, harvesting start by cutting corn stalks, collecting stalks in several groups in small area, then peeling process by manpower. After the peeling process, load corn cob in sack then distribute to thresher machine location. Contrary, in the new harvesting pattern, corn harvesting practice begin with
removing corn ears from the stalks in stand position then load into sack without peeling and ready to transport towards location of the peeling-thresher machine.

Furthermore, technological input remove employee for peeling and reduce employee when thresher process so that optimize the cost production. New approach on harvesting pattern via dissemination of dual functioning machine (peeling and threshing) simplified than the old that existed in POKTAN Dusun Puncak and POKTAN Dusun Beringin in Tutuwoto village. Therefore, farmers group association, local goverment, corn industries, and universities should provide the accessibility or availability of this proper machine for corn farmers with similar topography condition particularly in Gorontalo province.

**Figure 4.** Changing pattern of corn farming practices before and after dissemination of portable combining machine (peeling-thresher machine).
In Figure 5 were displayed corn peeling and threshing practices of farm employee using portable dual functioning machine. Applying peeling-thresher machine as appropriate technological input in sloping agriculture especially for Tutuwoto corn farmers (POKTAN’s members) have three benefits; (1) picking corn ears was performed on standing plants without cutting the stalk at the base (accelerate first step when harvesting process); (2) speed up peeling process without hired labour; (3) eliminating and reducing number of employment particularly in peeling and threshing practices.

**Table 6. Comparison of harvest and post-harvest cost (before and after peeling-thresher input).**

| Item                                      | Harvest and post-harvest cost (before) | Units | Rp/units | Total Cost, Rp |
|-------------------------------------------|----------------------------------------|-------|----------|----------------|
| 1  Cutting the stalk (3 labour/4 days)    | 12                                     | 100,000 | 1,200,000       |
| 2  Peeling (7 labour/7 days = 288 sack)   | 288                                    | 10,000  | 2,880,000       |
| 3  Distribution to thresher location      | 288                                    | 4,000   | 1,120,000       |
| 4  Thresher process (Kernel= 140 sack)    | 140                                    | 5,000   | 700,000          |
| 5  Man of thresher process (10 labour/ day) | 10                                    | 80,000  | 800,000          |
| 6  Transportation to asphalt road (140 sack) | 140                                   | 5,000   | 700,000          |
| 7  Transportation to warehouse (buyer)     | 140                                    | 5,000   | 700,000          |
| 8  Price of sack (piece)                  | 140                                    | 3,000   | 420,000          |
| **Total (before)**                        |                                        |        |           | **8,520,000**   |

| Item                                      | Harvest and Post-harvest (after)      | Units | Rp/units | Total Cost, Rp |
|-------------------------------------------|---------------------------------------|-------|----------|----------------|
| 1  Distribution to thresher location      | 288                                    | 4,000 | 1,120,000       |
| 2  Transportation to asphalt road (140 sack) | 140                                   | 5,000 | 700,000          |
| 3  Transportation to warehouse (buyer)     | 140                                    | 5,000 | 700,000          |
| 4  Price of sack (piece)                  | 140                                    | 3,000 | 420,000          |
| **Total (after)**                         |                                       |       |           | **2,940,000**   |
| Total harvest and post-harvest cost (total before) |                       |       |           | **8,520,000**   |
| Total harvest and post-harvest cost (total after) |                     |       |           | **2,940,000**   |
| **Capital Gain (optimizing cost)**        |                                       |       |           | **5,580,000**   |
Table 7. Optimizing cost in harvest and post-harvest after appropriate technological input.

| No | Item                        | Cost (Rp) | Changing cost |
|----|-----------------------------|-----------|---------------|
| 1  | Pre-Harvest                 | 8,110,000 |               |
| 2  | Harvest and Post-Harvest    | 8,520,000 | 8,520,000     |
| 3  | Unexpected Expense (5%)     | 831,500   |               |
|    | **Before**                  | **17,461,500** |         |
| 1  | Pre-Harvest                 | 8,110,000 |               |
| 2  | Harvest and Post-Harvest    | 2,940,000 | 2,940,000     |
| 3  | Unexpected Expense (5%)     | 831,500   |               |
|    | **After**                   | **11,881,500** |         |
|    | **Gain**                    | **5,580,000** |         |

Table 8. Income generation of the corn farmer.

| No | Buyer                    | Yield (kg) | Price (Rp) | Gross sales (Rp) | Total cost (Rp) | Net-profit (Rp) |
|----|--------------------------|------------|------------|------------------|-----------------|-----------------|
| 1  | Authorized buyer         | 8,400      | 2,700      | 22,680,000       | 17,461,000      | 5,219,000       |
|    |                          | 8,400      | 2,700      | 22,680,000       | 11,881,500      | 5,880,000       |
|    | Profit margin of own capital |           |            |                  |                 | 5,580,000       |
|    | Percentage (%)           |            |            |                  |                 | 51.67%          |
| 2  | Middlemen/Collectors     | 8,400      | 2,500      | 21,000,000       | 20,015,500      | 984,000         |
|    |                          | 8,400      | 2,500      | 21,000,000       | 14,435,500      | 6,564,500       |
|    | Profit margin of loan capital |          |            |                  |                 | 5,580,500       |
|    | Percentage (%)           |            |            |                  |                 | 85.01%          |

3.2. Labour cost

In this study case, function of technological input is as financial support for corn producer to gain extra income through intervention farm worker cost. In Table 6, after dissemination of peeling-thresher machine, corn farmer with the help of his family i.e. wife or child can finish removing the ears without hired labour for 1 hectare. The cost of family labour at this study was considered as being nil. As a result, corn producers do not have to pay labour to work for cutting corn stalk and peeling activities because of changing pattern from cutting corn stalk to removing corn ears that its process is performed by farmer’s family; also, peeling process is by manpower to machine. Hiring labour is unavoidable because old harvest pattern is performed by manpower to cutting the stalk and peeling process.

Table 7 illustrated that have occured significantly changing on expenditure of at-post-harvest. Before presence of dual functional machine (peeling and threshing) as technological input, harvest and post-harvest cost is at Rp8,520,000, compared after intervention decreased at Rp2,940,000. There is optimizing cost or capital gain that reached Rp5,580,000, which the gain can cover 68.80% of pre-harvest expenses. The mechanization of peeling and threshing practices have minimized labour cost; meanwhile, it has added farmer income. Additionally, rising revenue from farmers as machine adopter will reduce loan amount to middlemen for pre-harvest activities in the next seasonal growing.

3.3. Income Generation

Finally, role of proper technology is exceedingly crucial to raise economic condition of corn farmer especially to eliminate or reduce dependence from middlemen capital. Previous study, [15] Arsyad et al (2018) stated that role of middlemen is detrimental for farmers due to discrimination price and high interest. In addition, profit improvement will be expected reduce farmers’ dependence to take debt for
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pre-harvest cost. Moreover, in the next growing season, multiply revenue from the loan capital user will help financial support to start cultivation.

In terms of net earnings, own and loan capital received Rp10,799,000 and Rp6,564,000, respectively. Own capital farmer recorded 51.67 % rising income, compared loan capital user by 85.01% of increasing income. Corn farmers of POKTAN members recorded multiply net earnings after dissemination of the proper insruments for sloping agriculture in mountain and hilly area in Tutuwoto village, Gorontalo Province.

4. Conclusions
Usage of portable combine machine, thresher-peeler corn, by farmer shorten and simplify previous pattern on harvest and post-harvest in Tutuwoto Village, Gorontalo Province. Undoubtedly, the peeling-thresher machine’s implementation is so successful as to exert operational cost on sloping agriculture in study case location. As a result, adoption of proper technological input reduces labour fees and simultaneously increases corn farmer revenue drastically, mainly for loan capital users.

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