The optimization of agricultural machinery utilization in enhancing the implementation of modern agricultural programs

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Abstract. The provision of agricultural machinery in the Modern Agriculture Program is to overcome labor shortages. However, the utilization of agricultural machinery aid is underutilized. This study aims to analyze the optimization of the use of agricultural machinery in enhancing the implementation of modern agricultural programs. West Sumatera, Central Java, Banten, Bali, and South Sulawesi were purposively chosen as the study areas. The study was conducted in 2017. Respondents of this research were policymakers from central to local institutions, key informants, extension agents, agricultural machinery service providers (UPJA), and farmers. The method used was descriptive explanatory and financial analysis. The results showed that the utilization of agricultural machinery in the Modern Agricultural Program was still not optimal. It was still underutilized. There were several obstacles, both from economic and social aspects. The utilization of 4-wheel tractors and rice transplanters has not been economically managed. As a result, they cannot generate funds for equipment maintenance and the development and UPJA’s sustainability. Not all types of agricultural machinery are socially suitable for farmers' needs. There is a competition between agricultural machinery uses and workers. Moreover, not all local governments fully supports agricultural machinery uses. To optimize and succeed on the modern agriculture program implementation, agricultural extension workers with certification as UPJA Facilitators are required.

1. Introduction

The higher wages of non-agricultural workers relative to agricultural workers encourage workers to shift to non-agricultural activities. The workers shifting encourages the use of agricultural machinery in agriculture, including rice farming [1]. The use of agricultural mechanization will reduce labor per unit of land [2-4]. Agricultural mechanization strategies also play an essential role in the acceleration of agricultural productivity [1].

The share of labor costs to the total farming costs shows a high proportion. The use of agricultural mechanization is significantly increasing farmland and reduce labor costs [3]. The Government's modern agriculture program aims to overcome labor shortages, improve labor productivity and reduce farming costs through Government machinery assistance. However, the utilization of agricultural machinery is currently under-utilized. Various obstacles are found in the Modern Agricultural Programs implementation. One of the obstacles is accessibility of institutional equipment service and lack of farmer skills in machinery troubleshooting. Both aspects will affect the cost of agricultural machinery uses [5].

The Modern Agriculture Program is defined as a farming activity carried out through agricultural mechanization [6]. The agricultural machinery grant to institutions, namely Agricultural Equipment and
Mechanization Service Management Unit (AEMSM=UPJA), is managed by farmer groups or Gapoktan in which farmer group manages farm land as pilot project with an area of 100 ha. This study aims to analyze the optimization of the use of agricultural machinery in enhancing the implementation of modern agriculture programs.

2. Methods

The five provinces were purposively chosen for the research location. The areas where the Modern Agriculture Pilot activity (MAP) located, namely Sukoharjo in Central Java and Pandeglang in Banten, were selected to represent Java Island. Meanwhile, Padang Pariaman in West Sumatra, Klungkung in Bali, and Soppeng in South Sulawesi were represent Outside Java. The survey was conducted in 2017.

The respondents in the study were (1) leaders of policy-making institutions from the center to the regions; (2) key informants (farmer contacts, village officials, private extension agents); (3) farmer groups; (4) extension workers; (5) Machinery Service Business (UPJA), and (6) farmers.

The data collection method was using focus group discussion for respondents of leaders of policy-making institutions and key informants. Interviews using questionnaires were conducted to collect the data at the UPJA, farmer groups, and farmers. The sample number of farmers, extension worker, UPJA, and farmer groups in each location were 30 farmers, two extension workers, two UPJA (each for UPJA who received assistance and UPJA who did not receive Government aid), and two farmer groups. Therefore, the total samples in all provinces were 150 farmers, 25 extension workers, 10 UPJAs, and ten farmer groups. The refore, the total samples in all provinces were 150 farmers, 25 extension workers, 10 UPJAs, and ten farmer groups. The data were descriptively analyzed using financial analysis. The optimization level of agricultural machinery utilization is analyzed using the R/C ratio and the land area served by the machinery. The discussion focuses on the types of 4-wheel tractors, combine harvesters, and transplanters.

3. Results and discussion

3.1. Implementation of modern agriculture program (MAP)

The management of agricultural machinery assistance through existing institutions (UPJA, farmer groups, and Gapoktan), started in 2017. It is also managed by the Agricultural Machinery Brigade [7]. The agricultural machinery brigade at the farmers' group/UPJA level in Klungkung, Bali, is organized by Subak.

3.2. Optimization of the four-wheel tractors utilization

The analysis results showed that four-wheel tractors, in general, has not been managed on a business practice. The management has not taken into account the balance of income and expenditure of equipment operation. As a result, UPJA, in general, has not been able to generate funds for equipment maintenance and business development (Table 1).

Using service area criteria, the utilization of the 4-wheel tractors by UPJA MAP in Sukoharjo, Central Java, and non MAP UPJA in Pandeglang, Banten were good. In contrast, UPJA MAP in Soppeng, South Sulawesi was at low level, and UPJA MAP in Padang Pariaman, West Sumatera, was at medium level. However, using the R/C ratio indicator, the UPJA in Sukoharjo, Padang Pariaman, and Pandeglang were in the medium category, while UPJA in South Sulawesi was at low level. The differences of R/C occured due to differences among operating costs of UPJAs, especially in the components of maintenance and operator costs. The factors that influence the use of agricultural machinery are the specifications of the tools, brands, types, and conditions of the land, operators, and technicians' management. The most significant barrier to enabling smallholder access to proper mechanization is a mismatch between the economies of scale of machines and farm size [8]. The use of 4-wheel tractors is limited to land with flat and wide land conditions [9]. Many of the lands are dispersed fields, making them unsuitable for large machinery. In the Philippines,
the awareness of Filipino farmers to adopt agricultural machinery is still low because financial problems hamper it. Due to this reason, efforts are made to establish agricultural machinery training centers [10].

**Table 1.** Optimization of the 4-wheel tractors from the economic aspect of MAP and non-MAP UPJA 2017.

| Description                        | MAP UPJA                  | Non-MAP UPJA               |
|------------------------------------|---------------------------|----------------------------|
| 1. Province                        | Central Java              | S.Sulawesi                |
| 2. Districts                       | Sukoharjo                 | Soppeng                   |
| 3. Name of UPJA                    | Bagiyo Mulyo              | Semangat, Limo Sakato     |
| 4. Cultivated area/season/tool     | 80 ha                     | 4-5 ha                    |
| 5. Rental cost (IDR/ha)            | 750,000                   | 800,000 - 1 million       |
| 6. Form of cooperation             | profit sharing            | Fix deposit/season profit sharing |
| between operator-UPJA              |                           | profit sharing            |
| 7. UPJA section                    | 60% net yield             | 30% gross yield           |
|                                   | Rp1.5 million/Season      | 1/3 gross yield           |
| 8. Operator wages                  | 40% net yield             | 30% gross yield           |
|                                   | 0.84                      | 40% gross yield           |
| 9. R/C Rasio                       | 1.61                      | 1.39                      |
| 10. Optimization of utilization   | medium                    | low                       |

**Table 2.** Utilization of 4-wheel tractors from social aspects of MAP and non-MAP UPJA 2017.

| Description                        | MAP UPJA                  | Non-MAP UPJA               |
|------------------------------------|---------------------------|----------------------------|
| 1. Province                        | Central Java              | S.Sulawesi                |
| 2. Districts                       | Sukoharjo                 | Soppeng                   |
| 3. Name of UPJA                    | Bagiyo Mulyo              | Semangat, Limo Sakato     |
| 4. Acceptable by farmers           | high interest             | low interest, no          |
| 5. Competition with farmworkers    | no                        | yes                       |
| 6. Competition with external machine | no                        | No                        |
| 7. Competition with 2-wheel tractor | yes                       | no, to complement no, dominant |
| 8. Youth interest as UPJA          | high                      | Low                       |
| 9. Support/attention from local government | high                    | low                       |

**Note:** MAP= Modern agriculture program (UPJA that obtains agricultural machinery assistance ) UPJA= Machinery Service Business

The 4-wheel tractors did not compete with planting workers from the social aspect because this competitive condition was exceeded during the previous introduction of 2-wheel tractors (Table 2). Farmers' interest in using 4-wheel tractors has not been fully developed, and also because the number of equipment was still limited. However, 4-wheel tractors were more efficient than 2-wheel tractors [11].
The interest of youth to become operators was high because these activities are a good source of income. However, youth interest to become operators was low for areas with low utilization of agricultural machinery. A common challenge is a lack of operating, maintaining, and repairing of machinery [12].

3.3. Optimization of the combine harvesters utilization

There are two types of combine harvester assistance, namely large and mini combine harvesters. From an economic perspective, the combined harvester can generate relatively high income for the operator and UPJA compared to 4-wheel tractors and transplanters. The machinery rental fee varied on per unit weight of grain. There were also widely practiced a profit sharing per unit area. Renting a combine harvester with a fee system of per unit weight of grain was the most profitable for the combine harvester owners if the yield was high.

By analyzing the R/C ratio and the area cultivation, the utilization of combine harvesters through independent management by UPJA Spirit in South Sulawesi showed an optimal level (Tabel 3). However, there was no consistent relationship between program UPJA and non-program UPJA management in optimizing equipment utilization. Meanwhile, UPJA Independent (i.e., UPJA that did not get machinery assistance) showed good machinery utilization performance.

The use of a combine harvester in Gowa District increased the farmers’ income by 15% compared to conventional harvesting and the labor was more efficient [13]. Similarly, harvesting with a combine harvester was more efficient than that of manual cutting and threshing [11]. The results showed that, statistically, using a combine harvester increased the average productivity by 0.16 tonnes/ha, or nearly 3%.

Table 3. Optimizing the utilization of combine harvesters from the economic aspect of the research site of MAP and non-MAP with government aid and independent UPJA 2017.

| No. | Description                  | MAP UPJA          | Non-MAP UPJA with aid | Independent UPJA |
|-----|------------------------------|-------------------|-----------------------|------------------|
|     |                              | Central Java      | S. Sulawesi           | W.Sumatera       | Bali             | Banten           |
| 1.  | Name UPJA                    | Bagiyo Mulyo      | Semangat              | Farmers Group    | Subak Kusamba    | No name          |
| 2.  | Cultivated area/season       | 10-12 Ha          | 50 Ha                 | 2-5 Ha           | 10 Ha            | 40 Ha            |
| 3.  | Rent value                   | Rp2 million/ha    | *bawon* of rice 9:1   | *bawon* 12%      | Rp55,000/ kw grain | a. Rp50,000/kw grain |
|     |                              |                   |                       |                  | b. Rp3 million/ha |
|     |                              |                   |                       |                  | c. *bawon* 7:1   |
| 4.  | Form of cooperation *)       | profit sharing    | fixed deposit **)     | profit sharing   | profit sharing   | profit sharing   |
| 5.  | UPJA section                 | 60% net result    | Rp25 million **)      | 30% gross result | 1/6 net result   | 1/3 gross result |
| 6.  | Operator fee                 | 40% net result    | 30% gross result      | 40% gross result | 5/6 net result (5 people) | 1/3 gross result |
| 7.  | R/C Ratio                    | 1.78              | 1.89                   | 1.41             | 1.16             | 1.83             |
| 8.  | Utilization optimization     | medium            | good                   | low              | low              | good             |

Note: *) between operators and UPJA; **) per season
From the social aspect, large combine harvesters were in great demand by farmers, especially for rice fields with technical irrigation and good drainage. The dependence of farmers on combine harvesters in Soppeng and Pandeglang was high. This dependency could encourage the entry of combine harvesters from outside of the region. By using a combine harvester, grain quality and rice productivity are higher due to reducing yield loss. Power thresher was dominant for areas where harvest labor is limited, except for Pandeglang, where harvesting workers were using both power thresher and manual systems (Table 4).

Table 4. Utilization of combine harvester from social aspects at the research site MAP and non-MAP with government aid and independent UPJA 2017.

| UPJA No. | Description | MAP UPJA | Non-MAP UPJA | Independent UPJA |
|----------|-------------|----------|--------------|------------------|
| 1.       | Name UPJA   | Bagiyo Mulyo | Semangat Farmers group | Subak Kusamba |
| 2.       | Acceptable by farmers | low desirable, very interested | low interested | low desirable, yes/no |
| 3.       | Competition with workers | no | no | yes |
| 4.       | Competition with external machine | no, yes, from Wajo | no (low desirable) | yes, from other villages |
| 5.       | Competition with power thresher (pt) | no, pt more dominant | no, combine dominant, pt to complement | no, pt to complement |
| 6.       | Youth interest as operator | low | medium | high |
| 7.       | Support* | high | low | high |

Note: *) attention from local Government

3.4. Optimization of the transplanter utilization

From the economic aspect, the use of transplanters was not yet a reliable business for UPJA's cash income. The form of cooperation between UPJA and operators was profit sharing. The optimal use of transplanters was found only at UPJA MAP in Sukoharjo. The transplanters used by UPJA Sinar Tani (Banten) was moderate, while the other UPJAs’ transplanters uses were not optimal (South Sulawesi and West Sumatera). There was optimal in Bali (Table 5).

From the social aspect, the transplanter (Yanmar brand) was very attractive to farmers in Sukoharjo District but it was hindered by the lack of tray equipped machinery even though additional wood trays might have been installed. In South Sulawesi and West Sumatra, there were no demand for transplanters due to soil condition that is deep muddy, so it could not hold the transplanter weight. In addition, tabela is preferable to transplanter. The direct seed planting system (tabela) is a system of planting rice without going through nurseries and transferring seeds. In Banten and the Subak Brigade in Klungkung Bali, there were demand for transplanters. There is no competition with plantation workers. Transplanters were used intensively in Sukoharjo, Central Java. In Soppeng, South Sulawesi, transplanters complement farmworkers who were still dominantly needed to plant using the tabular system. However, in Banten, there were still a lot of manual laborers, so there was a competition with plant workers. Rice transplanter is preferred because
it is easy to operate and reduces marginal losses [14]. The rice transplanter is considered an excellent choice to speed up planting and reduce the number of workers (Table 6).

Table 5. Transplanter utilization from economic aspects at the research site of MAP and non-MAP, 2017

| No. | Description                          | MAP UPJA      | Non-MAP UPJA | Independent UPJA |
|-----|--------------------------------------|---------------|--------------|------------------|
|     |                                      | Central Java | S. Sulawesi  | W. Sumatra       | Bali  | Banten |
| 1   | Name UPJA                            | Bagiyo Mulyo | Semangat Limo Sakato | Subak Kusamba | 2014-2015 | 2015/16 | 2016 |
| 2   | Year of assistance                   |              |              |                 |       |       |
| 3   | Cultivated area/season/tool          |              |              |                 |       |       |
| 4   | Rent value (IDR/ha)                  | 750 thousand | not used     | not used        | 6 ha  | 15 ha |
| 5   | Form of cooperation between operators and UPJA | profit sharing | not used | not used | profit sharing |
| 6   | UPJA Section                         | 60% net result | not used | not used | 25% net result |
| 7   | Operator fee                         | 40% net result | not used | not used | 75% net result |
| 8   | R/C ratio                            | 2.00          | not used     | not used        | 1.28  | 2.11 |
| 9   | Utilization optimization             | Good          | not available | not available |       |       |

Table 6. Utilization of transplanter from social aspects at the research site of MAP, non-MAP and independent UPJA 2017.

| No. | Description                          | MAP UPJA       | Non-MAP UPJA | Independent UPJA |
|-----|--------------------------------------|----------------|--------------|------------------|
|     |                                      | Central Java  | S. Sulawesi  | W. Sumatera      | Bali  | Banten |
| 1   | Name UPJA                            | Bagiyo Mulyo Semangat Limo Sakato Subak Kusamba | 2014-2015 | 2015/16 | 2016 |
| 2   | Acceptable by farmers                | Very interested | not accepted | not accepted |       |       |
| 3   | Competition with farmworkers         | No             | Yes          | No               | Yes   |       |
| 4   | Competition with external tools      | No             | “tabela’ is preferred | “tabela’ is preferred | No | No |
| 5   | Youth interest as operator Support   | Low            | Low          | Low              | Low   | Low   |
| 6   | Support *)                           | Very high      | Low          | Low              | Yes   | Low   |

Note: *) attention from local Government; ‘tabela’: direct seed planting
4. Conclusions

The performance of the use of agricultural machinery in the Modern Agriculture Program varied among regions. The utilization of 4-wheel tractors and transplanters has not been managed in a business practice. The criteria for the area of land served and the R/C showed that it was not optimal. There were still some obstacles. Farmers have not achieved the optimal service area as a source of income, while maintenance costs were relatively high. Not all machinery were socially accepted by farmers due to farmers perception that there was a competition with farm worker. Moreover, not all local governments provided full support.

To further optimizing the use of agricultural machinery in encouraging the implementation of the Modern Agriculture Program, the policies that should be carried out are (1) the determination of prospective farmers and prospective locations should be carried out appropriately so that the assistance of machinery is under the needs of farmers and local conditions, (2) the Government full facilitate training to improve the ability of UPJA/Gapoktan/farmers management to operate agricultural machinery, (3) the Government should facilitate workshops and complete spare parts to overcome equipment damage, (4) it is necessary to take appropriate and firm sanctions for UPJA who do not use agricultural machinery properly.

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