Operational performance of agricultural machineries managed by custom hiring (UPJA) in Banyumas district of Central Java province

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Abstract. Agricultural mechanization has important role in increasing capacity, efficiency, and effectiveness of agricultural production process. In order to mechanize Indonesian agricultural system, Ministry of Agriculture has facilitated farmers with many agricultural machineries. Farmer institutions that were designated to utilize and manage those agricultural machineries are Agricultural Machinery Custom Hiring (UPJA). In this research, the operational performances of agricultural machineries managed by the UPJA in Banyumas District were studied. The research were done by desk study, focus group discussion, field survey to 7 UPJA, and measuring the performance of machineries utilized by those UPJA. The results showed that all of UPJA were in beginner status. The common owned and operated agricultural machinery was hand tractor, while four wheel tractor, rice transplanter, power weeder, and rice combine harvester were limited. In general the operational performances of the machines were low. The most factors affected the performance were time required for transportation from garage to the field. In case of hand tractor, the time consumed was 9.46% of total working hour. For four wheel tractor, rice transplanter, and rice combine harvester, the time required for transportation were 4.19%, 8.16%, and 7.18% respectively. The other factors slightly affected the performance were time losses due to machine preparation and machine trouble. It is suggested to facilitate farm road and towing truck to transport the machines, or develop garage not far from field.

1. Introduction
Main strategy of Indonesian agricultural development 2013-2045 is “development of sustainable agricultural bio-industry”. The vision is guided to maintain the sustainability of agricultural production process in term of balancing and optimizing in utilization of socio-economic, physic, and bio resources. Agricultural production system should be run in holistic and integrated way by optimizing agro-ecosystem naturally [1,2].

As an industrial activity, agricultural bio-industry is a business-oriented task that focused on bio-based economy. Engineering aspects in term of mechanization is an important system to support this bio-industrial process, primary and secondary, even diversification of the products. Agricultural mechanization has important role in increasing capacity, efficiency, and effectiveness of agricultural
process. Agricultural mechanization also potentially increase the planting index and product quality. However, it could only be reached when planning, selecting, and utilizing of infrastructure, such as farm machineries, were conducted in proper and good management [3].

In general, agricultural mechanization aimed to increase working and land productivities, and decrease production cost as well. Utilization of machineries is intended to improve efficiency, effectiveness, productivity, product quality, and reduce working load of farmer [4]. A fundamental problem faced in Indonesian agricultural development is their low capabilities in control of agricultural mechanization especially in term of agricultural machineries procurement by farmer. The low capabilities take effect in capacity of farmer to select and use proper technology as well as agricultural machineries [5]. Intervention by government in order to improve this capability is a must.

In order to modernize or mechanize Indonesian agriculture, Ministry of Agriculture has facilitated farmer groups with many agricultural infrastructures. During 2012-2017 the government has introduced 119,078 unit of hand tractor, 6,330 four-wheel tractor, 72,195 water pump, 16,286 rice transplanter, 17,268 rice combine harvester, 303 corn harvester, 9,992 corn-sheller, 12,291 power thresher, 498 dryer, and 1,466 rice milling unit [6]. These assistances have positive impact such as: increasing 2.4 million ha planting area, decreasing 33% cost for soil tillage, and decreasing 5% harvesting losses.

Farmer organizations or institutions formed and designated to utilize and manage the agricultural machineries is Agricultural Machinery Custom Hiring (UPJA, Usaha Pelayanan Jasa Alsintan). This organization has important role to assure mechanization practices in the UPJA’s region. Recently, the problems faced by UPJA is not only their capability in utilizing agricultural machineries, but also their capability in procurement (due to limited budget), management, and maintenance as well. The attention should be taken by UPJA that agricultural machineries are asset in agri-business system, such that proper management system approach is needed [7]. In this preliminary research, the managerial performance of agricultural machinery custom hiring (UPJA) as main driver in implementation of mechanization was studied. The results will be used as input parameters in developing implementation model of mechanization for rice production system.

2. Material and Method

The research was conducted in 7 of 49 UPJA in Banyumas district, Central Java. The research was done by desk study, focus group discussion, and field survey. Some questionnaires were developed for this purpose.

There are two performance objects were observed: UPJA’s related object, and agricultural machinery related object. In the UPJA’s related object there were observed some aspects of: UPJA status, planting area, harvesting area, UPJA’s covered area, planting index, farm machinery mobility, technical and economical management. Simultaneously, there was also conducted area identification in term of: agroecosystem, existing technology, and existing institutions related to UPJA. In the machinery related object there were observed: types and number of machinery, specification, working capacity, hiring cost, hiring management, fixed and variable cost, utilization index, and breakeven point of each machine.

3. Results and Discussion

3.1. Agroecosystem of Banyumas Region

Banyumas District is situated in South Western part of Central Java Province. Area of Banyumas District is 132,760 ha with some lowland and hilly area. Average elevation of Banyumas is 3400 m above sea level. Topography is varied from flat to sloppy. The hilly area, at the Slamet Volcano slope, is located in the Northern Part of the district. The lowland area is located along Serayu River Valley. Rice field area in Banyumas District is 32,255 (26%) ha and agricultural area non-rice field is 61,590 ha (46%). Banyumas has a tropical monsoon climate with rainfall concentrated in October to March.

Sample area was spread from East to West in the middle area of Banyumas. Topography in sample area is flat to light sloppy. Soil is fertile because of minerals from Slamet Volcano. Rice fields in sample area are irrigated from some small irrigation system in Banyumas.
3.2. Agricultural Machinery Custom Hiring in Banyumas

There are 49 agricultural machinery custom hiring (UPJA) available in Banyumas district. All of the UPJA are in beginner status. Table 1 presents seven of those 49 UPJA representing their status, working area, and other criteria. It shows that the working area vary from 24 ha to 131 ha. In correlation with effectiveness of UPJA it is recommend that due to working performance of the machineries, there will be better if minimum working area of each UPJA is 100 ha [8]. Therefore only half of UPJA in Banyumas could potentially perform their efficient and effectiveness in operating and managing their mechanization infrastructures. It is suggested that especially for some UPJAs with narrow working areas are join or regrouping with nearest UPJA such that minimum working area or economies scale is reached.

Table 1. Status and working area of selected UPJA in Banyumas District

| No | UPJA       | Village   | Sub-District | Status   | Working Area (Ha) |
|----|------------|-----------|--------------|----------|-------------------|
| 1  | Tani Maju-1| Karangklesem | Pekuncen     | Beginner | 122               |
| 2  | Berkah Tani-1| Banjar Anyar | Pekuncen     | Beginner | 110               |
| 3  | Dasyani    | Pasir Kulon | Karang Lewas | Beginner | 33                |
| 4  | Raksa Niaga| Kutariman  | Kedung Banteng | Beginner | 24                |
| 5  | Berkah Tani-2 | Beji      | Kedung Banteng | Beginner | 30                |
| 6  | Makmur Jaya| Klahang    | Sokaraja     | Beginner | 120               |
| 7  | Tani Maju-2| Karang Duren | Sokaraja     | Beginner | 131               |

The common owned and operated agricultural machinery is hand tractor (TR2), while four wheel tractor (TR4), rice transplanter, rice combine harvester, and post harvest machineries are still limited (Table 2). In general, types and number of agricultural machineries available in this region are not sufficient in order to support development model of mechanization for rice production system yet. Additional machineris, both in types and number, are needed. Even in case of hand tractor, some UPJA are still in lacking or minus status (Table 3). Facilitating program from government in introducing farm machineris is recommended to be continued.

Table 2. Ownership of main agricultural machinery

| No | UPJA     | Area (Ha) | TR-2 | TR-4 | Agricultural Machinery (unit) |
|----|----------|-----------|------|------|-------------------------------|
|    |          |           |      |      | Transplanter Combine Power pump Power thresher |
| 1  | Tani Maju-1 | 122 | 2   | 0   | 0 1 0 0                        |
| 2  | Berkah Tani-1| 110 | 2   | 0   | 0 0 1 0                        |
| 3  | Dasyani    | 33    | 4   | 0   | 0 1 2 1                        |
| 4  | Raksa Niaga| 24    | 2   | 1   | 0 1 0 1                        |
| 5  | Berkah Tani-2| 30  | 2   | 0   | 0 0 1 0                        |
| 6  | Makmur Jaya| 120  | 2   | 0   | 0 0 1 0                        |
| 7  | Tani Maju-2| 131  | 2   | 2   | 3 2 2 0                        |

Table 3 presents adequacy status of tractor in Banyumas. It shows that besides its lacking in number, the covered area of the tractor was still far from ideal. The ideal covered area of hand tractor is 20 ha per unit, and four wheel tractor is 100 ha per unit; therefore the ideal covered area of 16 hand tractors and 3 four wheel tractor is 620 ha, while the actual covered area was 246 ha (39.7%). Information from UPJA official and operator, it was due to low working capacity of the tractors because of worthy sizes and physical condition of land, difficulties in mobility or movements of tractor from one to other site, low skill in operating, and difficulties in managing soil tillage calendar. Majority of rice field has small size and without proper farm road. Some improvements such as rice production management and land consolidation are needed.
Table 3. Adequacy status of tractor

| No | UPJA            | Area (Ha) | Existing Machine Covered Area (ha) | Ideal Covered Area (ha) | Status |
|----|-----------------|-----------|-----------------------------------|-------------------------|--------|
| 1  | Tani Maju-1     | 122       | 0                                  | 20                      | -4 TR2 |
| 2  | Berkah Tani-1   | 110       | 0                                  | 30                      | -4 TR2 |
| 3  | Dasyani         | 33        | 0                                  | 20                      | -2 TR2 |
| 4  | Raksas Niaga    | 24        | 2                                  | 26                      | 140    |
| 5  | Berkah Tani-2   | 30        | 2                                  | 30                      | 40     |
| 6  | Makmur Jaya     | 120       | 2                                  | 40                      | -4 TR2 |
| 7  | Tani Maju-2     | 131       | 2                                  | 2                       | 100    |

Total 570 16 3 246 620

Table 4, Table 5, and Table 6 shows the adequacy status of rice transplanter, rice combine harvester, and power thresher in selected UPJA. Almost all of UPJA are in lacking status. It can be understood, especially for rice transplanter and combine harvester because there are new technology for rice production activity in this region. These machines are still very expensive and their availability, even in market, are still limited. For the existing machines, their covered area is very low due to lack of skilful operator. Some operators are still in training status.

Table 4. Adequacy status of rice transplanter

| No | UPJA            | Area (Ha) | Existing Number Covered Area (ha) | Ideal Covered Area (ha) | Status |
|----|-----------------|-----------|-----------------------------------|-------------------------|--------|
| 1  | Tani Maju-1     | 122       | 0                                  | 0                       | -4     |
| 2  | Berkah Tani-1   | 110       | 0                                  | 0                       | -4     |
| 3  | Dasyani         | 33        | 0                                  | 0                       | -1     |
| 4  | Raksas Niaga    | 24        | 1                                  | 0                       | -1     |
| 5  | Berkah Tani-2   | 30        | 1                                  | 0                       | -1     |
| 6  | Makmur Jaya     | 120       | 2                                  | 0                       | -4     |
| 7  | Tani Maju-2     | 131       | 3                                  | 60                      | 100    |

Total

Table 5. Adequacy status of rice combine harvester

| No | UPJA            | Area (Ha) | Existing Number Covered Area (ha) | Ideal Covered Area (ha) | Status |
|----|-----------------|-----------|-----------------------------------|-------------------------|--------|
| 1  | Tani Maju-1     | 122       | 1*                                 | 0                       | 100    | Enough |
| 2  | Berkah Tani-1   | 110       | 0                                  | 0                       | 0      | -1     |
| 3  | Dasyani         | 33        | 1*                                 | 0                       | 100    | Joint/hiring |
| 4  | Raksas Niaga    | 24        | 1*                                 | 0                       | 100    | Joint/hiring |
| 5  | Berkah Tani-2   | 30        | 0                                  | 0                       | 0      | -1     |
| 6  | Makmur Jaya     | 120       | 0                                  | 0                       | 0      | -1     |
| 7  | Tani Maju-2     | 131       | 2                                  | 131                     | 200    | Enough |

Table 6. Adequacy status of power thresher

| No | UPJA            | Area (Ha) | Existing Number Covered Area (ha) | Ideal Covered Area (ha) | Status |
|----|-----------------|-----------|-----------------------------------|-------------------------|--------|


In order to evaluate the effectiveness of machineries utilization, Table 7 presents comparison on working capacity of main agricultural machines in existing condition toward their capacity in the ideal condition. In general working capacity of machines was below the ideal. Characteristics of soil physic and land size are predicted as causal, because almost land or rice fields were not prepared and designed for mechanization use properly. In case of four wheel tractor and rice transplanter, the ratios were very low. In correlation with physical characteristic of the soil it could be understood because of low bearing capacity of almost soil in this area. Moreover, hardpan layer below the rice field was usually not formed yet, therefore the zinkage was deep. In term of the size of rice field, that usually in narrow condition, there was predicted that it bring about the big wheel tractor could not run effectively. A lot of time lost due to turning and adjusting implement. In case of rice transplanter, the low ratio is also predicted due to skill of operator that not familiar yet.

Table 7. Working capacity of main agricultural machinery

| No | Machine                  | Working Capacity (ha/hr) | Ratio (%) |
|----|--------------------------|--------------------------|-----------|
|    |                          | Average                  | Ideal     |
| 1  | Hand tractor (TR2)       | 0.05                     | 0.07      | 76.29     |
| 2  | Wheel tractor (TR4)      | 0.43                     | 0.60      | 71.67     |
| 3  | Rice transplanter        | 0.08                     | 0.12      | 66.67     |
| 4  | Combine harvester        | 0.15                     | 0.20      | 75.00     |

Besides the low working capacity in the field, there are another inefficiency problem in term of transportation time of machines from machine-pool to the field vice-versa, and transportation from a field to another field as well. It was found from the observation that transportation time was consume about 4.19-9.46 % of working time (8 hour). It consists of 9.46% time losses for hand tractor, 4.19% for four wheel tractor, 8.16% for transplanter, and 7.18% for rice combine harvester. These were due to distance from machine-pool to the field (0.50-4.96 km) that consumed 20.00-45.20 minute of transportation time. The other factors slightly affected the operational performance were time losses due to machine preparation or setting, and machine trouble. Therefore it is suggested to facilitate farm road and towing truck to transport the machines, or develop machine-pool (garage) not far from field.

The low efficiency has impacted to working cost of the machines. Extra time and fuel were consumed and it increases operational cost. However, almost UPJA have not included depreciation component in determination of working cost so that UPJA have valued their hiring cost lower than the ideal. Together with low covering area and low working time, the low of working capacity was also bring about the bigger breakeven point and the lower B/C ratio of machine. Table 8 presents breakeven point, in term of area should be covered, of main farm machineries operated by UPJA. It shows that breakeven points were two-three times from its ideal. Based on calculation formula, it was due to high operational cost and low working capacity. Therefore, to improve the breakeven value, the operational cost should be lowered and/or working capacity should be increased.
Table 8. Breakeven point of main agricultural machinery

| No | Machine                  | Breakeven Point (ha) | Ratio (%) |
|----|--------------------------|----------------------|-----------|
|    |                          | Average | Ideal |          |
| 1  | Hand tractor (TR2)       | 56      | 15-25 | 280       |
| 2  | Wheel tractor (TR4)      | 125     | 55-65 | 208       |
| 3  | Rice transplanter        | 74      | 40-50 | 164       |
| 4  | Combine harvester        | 109     | 45-55 | 218       |

Table 9 shows that except for four wheel tractor, B/C ratio of machines were in excess of 1.0. It means that in this area, rental of agricultural machinery is potentially profitable. With some improvements in operational and managerial skills, UPJA with working area bigger than 100 ha have potential to be main institution in driving agricultural mechanization or agricultural modernization.

Table 9. B/C ratio of main agricultural machinery

| No | Machine                  | B/C Ratio | Ratio (%) |
|----|--------------------------|-----------|-----------|
|    |                          | Average | Ideal |          |
| 1  | Hand tractor (TR2)       | 1.04     | >1.2   | 87        |
| 2  | Wheel tractor (TR4)      | 0.88     | >1.2   | 73        |
| 3  | Rice transplanter        | 1.09     | >1.2   | 91        |
| 4  | Combine harvester        | 1.17     | >1.2   | 98        |

As a driver of mechanization, performances of the UPJA have still to be improved. Some UPJA also still need additional machineries. In technical aspect, improvement of skills of both owner and operator, especially in operational, maintenance, and repair have to be increased. Empowering in management and business aspect should also be conducted. Detail calculation of machinery mobility should also be done for all machines in order to improve their efficiency as well as their effectiveness.

In general, although the existing UPJA in this region are still in beginner status, some UPJA with wide area have shows their potential tends in near future. Cooperation inter-UPJA are necessary to improve the utilization index of machineries. For UPJA have narrow areas are suggested to join or grouping with nearest UPJA to get ideal working area or economies scale.

4. Conclusion

1. Agro-ecosystem of Banyumas District is physically suitable for implementation of mechanization model for rice production system.

2. Some UPJA have potentially perform their efficient and effectiveness, however some UPJA with narrow working areas are suggested to join or regrouping with nearest UPJA to reach ideal working area or economies scale.

3. In general, numbers of agricultural machineries available in this region were not sufficient to support mechanization model for rice production system. Additional machineries, both in types and number, is needed

4. Almost machineries work under their capability (especially in working hour per year) therefore, break-even point of the machine was usually bigger than ideal

5. Transportation is a factor affected the operational performance of the machines. For hand tractor, the time consumed for transportation was 9.46 % of total working hour per day (8 hours), while for four wheel tractor, rice transplanter, and rice combine harvester, the time required for transportation were 4.19%, 8.16%, and 7.18% of total working hour respectively.
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References
[1] Anonymous 2007 Soil Ecology Learning Material (ET) and System of Rice Intensification (SRI) (Central Irrigation, Water Resources Research and Development Center, Ministry of Public Works)
[2] Purwantana B 2011 Studies of Energy Input on Rice Cultivation by System of Rice Intensification Method J. Agritech 31
[3] Rizaldi T 2006 Machinery and Tool (Medan: Department of Agricultural Technology, Faculty of Agriculture, Universitas Sumatera Utara)
[4] Ananto E, Handaka and Sutrisno 2007 Economic of Rice in Indonesia (Agency of Agricultural Research and development)
[5] Hadiutom K 2012 Agricultural Mechanization (Bogor: IPB Press)
[6] Anonymous 2018 Assistance of Farm Machinery 2012-2017 (Directorate of Farm Machinery, Ministry of Agriculture)
[7] Sutiarso L 2009 Development of UPJA Management Model (Reorientation and Reconstruction) (Yogyakarta: Universitas Gadjah Mada)
[8] Budiharti U, Jualiana R, Mulyani and Daragantina 2018 Implementation of Mechanization Model for Rice Production System and Strengthening Farmer Institutions in Sidowayah Village, Klaten District, Central Java Proceeding of the 9th International Symposium on Machinery and Mechatronics for Agriculture and Biosystems Engineering (ISMAB) (Jeju, Korea)