

PAPER • OPEN ACCESS

An energy needs analysis for agricultural sector in Indonesia

To cite this article: E R Widjaya *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **686** 012007

View the [article online](#) for updates and enhancements.

You may also like

- [The influence of the adequacy of training simulators on simulator planning training](#)
B Zh Kuatov, B K Kemalov and N K Yurkov
- [Assessing dietary adequacy and temporal variability in the context of Covid-19 among Indigenous and rural communities in Kanungu District, Uganda: a mixed-methods study](#)
G Scarpa, L Berrang-Ford, S Twesigomwe et al.
- [Modelling adequacy of calibration curves and dynamic characteristics of measuring instruments](#)
V A Granovskii and T N Siraia



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

An energy needs analysis for agricultural sector in Indonesia

E R Widjaya^{1*}, U Budiharti¹, and A Prabowo¹

¹Indonesian Center for Agricultural Engineering Research and Development (ICAERD)
Jl. Sinarmas Boulevard, Ds Situgadung, Pagedangan Tangerang-Indonesia

*Corresponding author: elitarahmarestia@pertanian.go.id; Elitar.ER@gmail.com

Abstract Agriculture sector contributes highly to the GDP of Indonesia. One of the strategies to increase the agricultural production is by accelerating the application of agricultural mechanization. Due to the limitation of manpower in agriculture, the use of agricultural machinery has increased massively since 2014. The index of mechanization has been leveraged from 0.015 in 1983 to 1.68 in 2018. The use of machinery in agriculture will continue to increase, given the adequacy levels of some machinery are still low. The adequacy level of available machinery was estimated at about 49.2% for 2-wheel tractors, 11.9% for 4-wheel tractors, 39.7% for water pumps. This paper estimates the energy use in agriculture by expanding the previous studies of the mechanization index and the adequacy level of agricultural machinery in Indonesia. Currently, the energy in agriculture is under the category of ‘Other Sector’ based on National Statistical Energy Report. Employing available data, this study estimates that the consumption of diesel oil (GasoilCN48) by agricultural machinery is approximately 1.5 million kL or about 82% of particular fuel consumption at ‘Other Sector’ of 2018 Report. Simulating to exponentially increase adequacy level of on-farm machinery (mechanization index up to 4.6 by 2028), the energy consumption of machinery may also grow equal to 3.5 million kL/year. The contribution of energy consumption from agricultural sector can be targeted to intensify the renewable energy application. The renewable energy has been disseminated progressively in agriculture sector. Those are biomass as heating fuel in grain dryers, solar energy to power water pumps, dual fuel (LPG/biogas & gasoline) engines and biodiesel (B30 to B100) for fueling the agricultural machinery with diesel engine. The B100 can be efficiently and effectively used as an alternate fuel for small diesel engines.

1. Introduction

The agricultural sector of Indonesia contributes highly to domestic income, especially those from rural communities. In this first semester of 2020 with an uncertain economic situation, agriculture is the only sector having a positive contribution to the national income [1]. As a tropical country, Indonesian will continue to focus on agriculture to self-sufficiency produce the food as well as being targeted to export agricultural commodities. One of the strategies to increase agricultural production is by accelerating the application of agricultural mechanization. The Ministry of Agriculture has been introduced agricultural machinery vastly since 2014. Government support by distributing agricultural machinery in 2016-2017 in Indonesia has a macro-level economic effect. Spending of 1% national



budget to agricultural machinery or other infrastructure contributed to a 0.33% increase in the production of agricultural sub-sectors, livestock, fishery and agricultural services in the region [2].

Compared to previous decades in socializing the mechanization, the latest dissemination of agricultural mechanization is more responsive due to the limitation of labor in agriculture and lack of interest of young people working in labor intensive farming. Besides, the problem of climate conditions has shortened the planting time; the use of agricultural machinery allows planting or harvesting faster and be done simultaneously. The use of agricultural machinery is also expected to increase the expansion of planting areas and increase the crop index.

The ongoing agriculture program is targeted to be advanced, independent and modern. Improvement of agricultural facilities and infrastructure, including agricultural equipment and machinery are still continuing. The facts of limited agricultural labor and shifting the extension agricultural areas into the locations with low population densities can intensify the use of mechanization in Indonesia.

The growth of agricultural production and mechanization in modern society will have an impact on energy needs. Currently, the consumption and planning of energy in agriculture are under the category of 'Other Sub Sectors' conducted by National Planning Institutions (Bappenas) or Ministry of Energy and National Energy Council (DEN). In fields, agricultural energy is usually obtained from supplies of transportation and household sector. To avoid some disturbances in the fuel supply in the agricultural sector, it may be necessary to do an analysis and planning of energy needs in agriculture.

Several institutions and references have presented analyses of energy consumptions and planning. A tool namely the LEAP model is well-known utilized by planners for projecting the energy needs[3][4]. In this model, the assumptions made by planners can affect the results. In this paper, an approach of energy estimation in agriculture presents a method and some assumptions that can be incorporated in the future energy needs analyses and planning. It uses the data associated with the target of increasing the index of mechanization. The potential use of mix renewable energy in the agricultural sector is also discussed in this paper.

2. Method of Analyses

2.1 Index of Agricultural Mechanization

The index of mechanization in agriculture can be expressed in three main resources: manual, human-animal and mechanical. The use of power starts from preparing the land, breeding, planting, weeding, pests / diseases management, harvesting and post harvesting. One quantitative measurement of the mechanization indexes developed by FAO is by calculating the ratio of power per hectare (horsepower / hectare) [5].

In addition to the parameters of the agricultural mechanization index, Indonesian Center for Agricultural Engineering Research and Development (ICAERD) also conducts a study on the adequacy level of agricultural machinery by mapping the population of agricultural machinery compared to the planting area and other technical assumptions such as working capacity and typology of mechanization suitability. The assumptions of covering area can be assessed by agricultural machinery as in Table 1.

Table 1. Assumption in simulating the adequacy level of agricultural machinery[6]

Type of machine	Assumption of covering area by mechanization	Notes
Hand tractor	80%	Able to operate in most area except land with <i>hardpan</i> > 30 cm
4 wheel tractor	40%	- Not applicable for terrace land - suitable for land with cone index < 2.5 - not applicable for small area

Type of machine	Assumption of covering area by mechanization	Notes
Rice transplanter	40%	- applicable for land with its slope < 15% (refer to OECD Test). The assumption based on available manual labor in planting and social response in adopting new method of seedling
Cultivator	30%	Applicable for small dry land and hills
Pump	100%	Mostly applicable in all locations
Power sprayer	100%	Mostly applicable in all locations
Combine harvester	40%	- Not applicable for terrace land - suitable for land with cone index < 2.5 - not applicable for small area applicable for land with its slope < 15% (refer to OECD Test).

Based on those assumptions, the adequacy level of available machinery in 2018 was estimated only at about 49,2% for hand tractors, 11,9% for 4-wheel tractors and 39,7% for water pumps [6].

2.2. Energy Consumption in Agriculture

The energy consumption in the agricultural sector is assessed based on the amount of fuel used by agricultural machinery for doing land preparation, planting, maintaining crops, and harvesting the paddy crops. Suarna 2000 [7] conducted an analysis of the energy needs in the agricultural sector in particular for the case study of Gorontalo Province. The approach was calculating the oil consumption of available machinery population with assumptions of operating time, covering area and average energy consumption per unit of the machine. The analyses of mechanization index and the adequacy level of machinery conducted by ICAERD also utilize available data of machinery population and similar parameters and assumptions such as covering area and operating times derived from the cropping index[6]. Following the study of mechanization index and adequacy level of machinery population, the analyses are then extended to study the energy consumption.

To energy consumptions of agricultural machinery was calculated as below [7]:

$$E = T \times I_e \dots\dots\dots (1)$$

$$I_e = O \times F \dots\dots\dots (2)$$

Whereas: E= Total oil consumption (liter/year)

T= number of machine population (unit)

I_e= energy intensity of each type of machine (liter/unit/year)

O= working hours (hours/year)

F= oil consumption (liter/hour)

The assumptions in estimating the use of energy was as follow:

Table 2. Assumption in calculating the fuel consumption

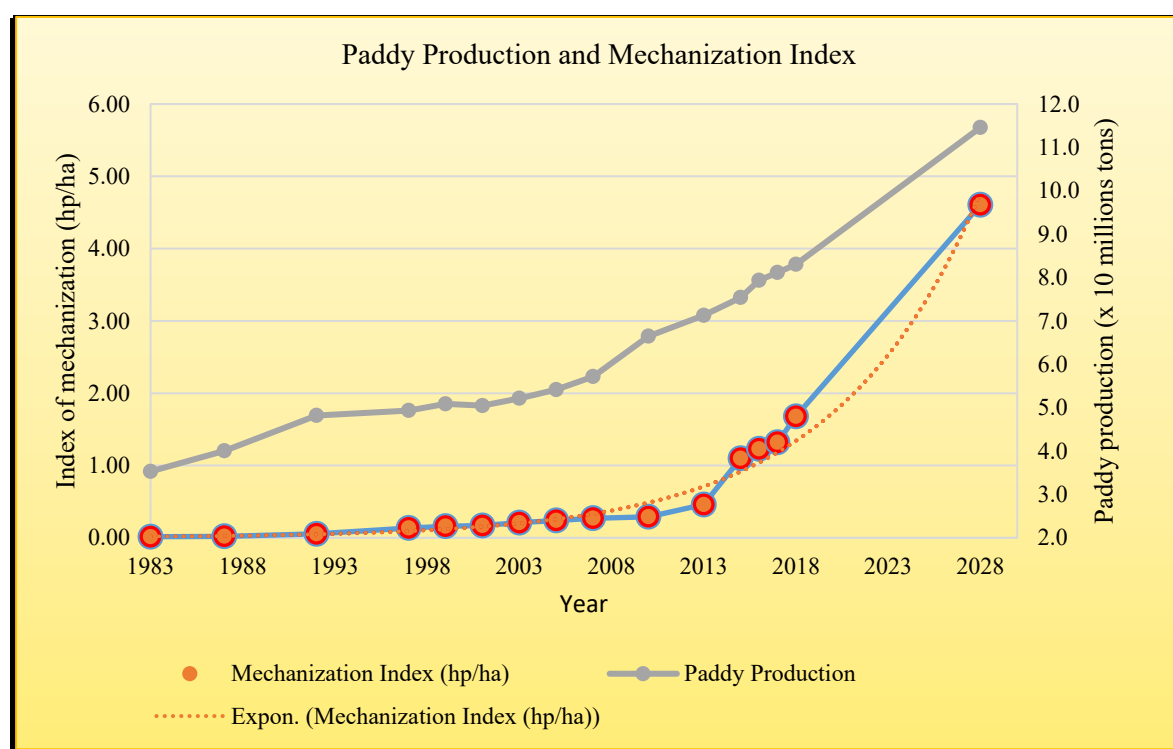
Type of machine	Type of fuel	Fuel consumption (l/hour)	Working hours/year	Covering area (Ha/season)
Two-wheel tractor	Biodiesel B30	1,1	600	20
Four wheel tractor	Biodiesel B30	2,8	650	80
Rice transplanter	Biodiesel B30	1,1	500	20
Cultivator	gasoline	1,1	300	10

Type of machine	Type of fuel	Fuel consumption (l/hour)	Working hours/year	Covering area (Ha/season)
Pumps	Gasoline / biodiesel B30	1,1	750	4-60
Sprayer	gasoline	1	1000	25
Combine harvester	Biodiesel B30	1,4	500	40

3. Results and Discussions

3.1. Index of Agricultural Mechanization

The quantitative measurement of the mechanization indexes developed by FAO is by calculating the ratio of power per hectare (horsepower / hectare) [5]. Figure 1 shows, in 2016, Indonesia had the mechanization index of 0.83 hp / ha. The FAO reported Vietnam mechanization index was 1.6 hp / ha, Thailand 2.9 hp / ha, Malaysia 5.7 hp / ha, and Japan 16 hp / ha in 2016. Dissemination of agricultural machinery was done in a massive scale between 2014 and 2018. The index of mechanization has been leveraged from 0.015 in 1983 to 1.68 in 2018 (Figure 1). At the year 1983 -2010, the mechanization index only grew averagely 1,4%/year, but in 2010 - 2018 the growth of mechanization index sharply increased averagely 23,4%.



Source: Index of mechanization data [5]

Paddy production data[8]

Figure 1. Index of Mechanization and Paddy Production in Indonesia

Figure 1 shows that there could be a correlation of increasing the index of agricultural mechanization to the increase of agricultural production. ICAERD together with Directorate of Agricultural Machinery, Ministry of Agriculture conducted field surveys in several regions in 2019 [6]. The surveys revealed that the use of mechanization could contribute significantly to the increase of cropping index, productivity, work efficiency and speed up the process of planting and harvesting [6]. Figure 1 is also projecting the

index of mechanization by exponential growth. By 2028, the mechanization index is expected to reach 4.61 hp/ha. With the target of production increase 3,8%/year, in 2028, the paddy production can reach 115 million tons/ha.

Increase of population and target in achieving self-sufficiency in a sustainable manner, the Ministry of Agriculture continues to use the strategy of optimizing the use of agricultural machinery, modern agricultural facilities and other infrastructures. Having positively grown on agricultural machinery utilization is also driven by the lack of labor in agriculture and lack of interest of young people working in agriculture.

3.2. Energy consumptions of agricultural machinery

The data of agricultural machinery population sourced from primary and secondary data, collected by ICAERD under the projects of Mapping Agricultural Machinery Population and Agricultural Machinery Policy Analyses conducted during the year of 2013-2019. Based on the calculation using the equation (1) and (2) and assumptions above, the estimated fuel consumption in 2018 by machinery type is shown as in Figure 2.

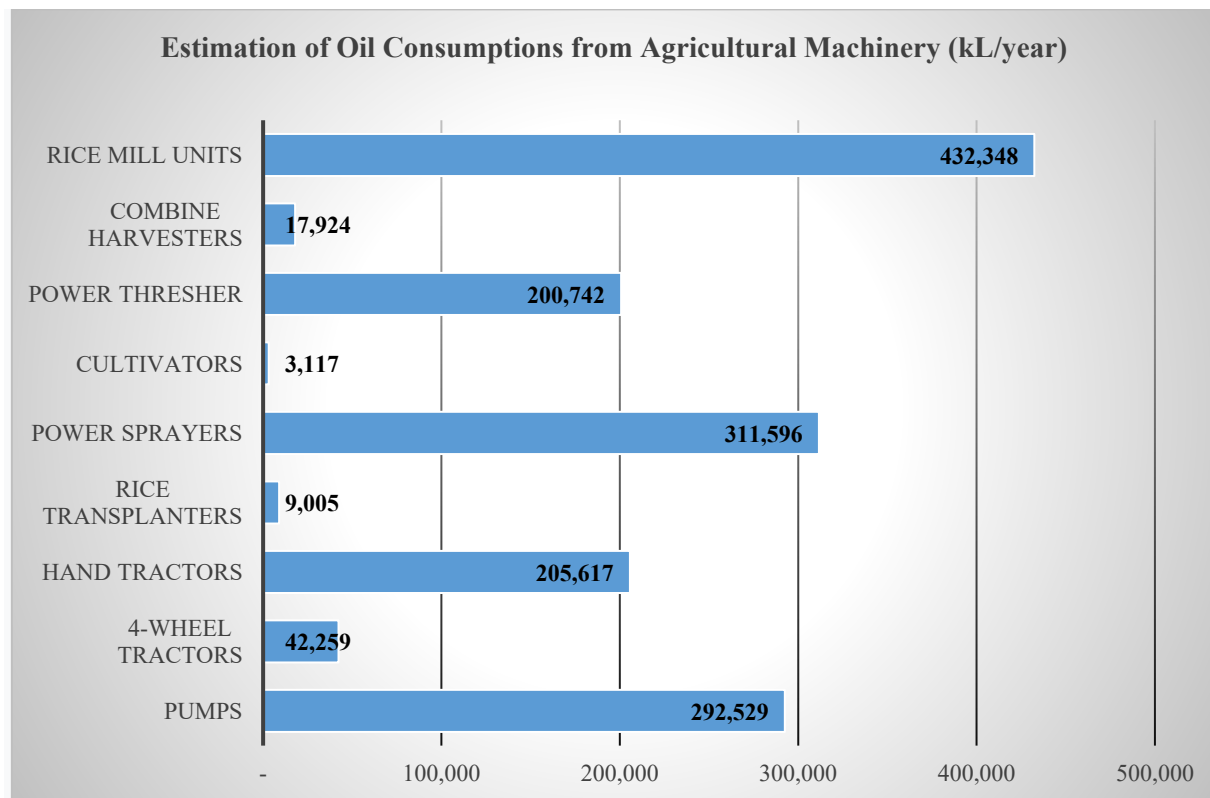


Figure 2. The estimate fuel oil consumption by agricultural machinery in 2018

The Statistic Energy Report 2018 issuing by Ministry of Energy 2018 [9] states that the diesel oil (GasoiCN48) consumption under the category of OTHER SECTOR was 1,844,472 kL. The total of fuel consumptions of agricultural machinery above contributes to about 82% of the diesel oil consumption in Other Sector. Given in the previous section that the adequacy level of some machinery is still low (under 50%), the population of some machinery such as tractors, pumps, combine harvester and transplanter will increase.

The previous section, the index of mechanization can be planned to increase up to 4,61 hp/ha by 2028. Based on the study of adequacy level of machinery [6], a simulation of on-farm machinery population

has been projected to reach the mechanization index. In line with the growth of index exponentially, the estimate of fuel consumptions will also grow exponentially, as in figure 3. The oil consumptions of particular on-farm machinery is expected to reach 35.6 million kilo Liters in 2028.

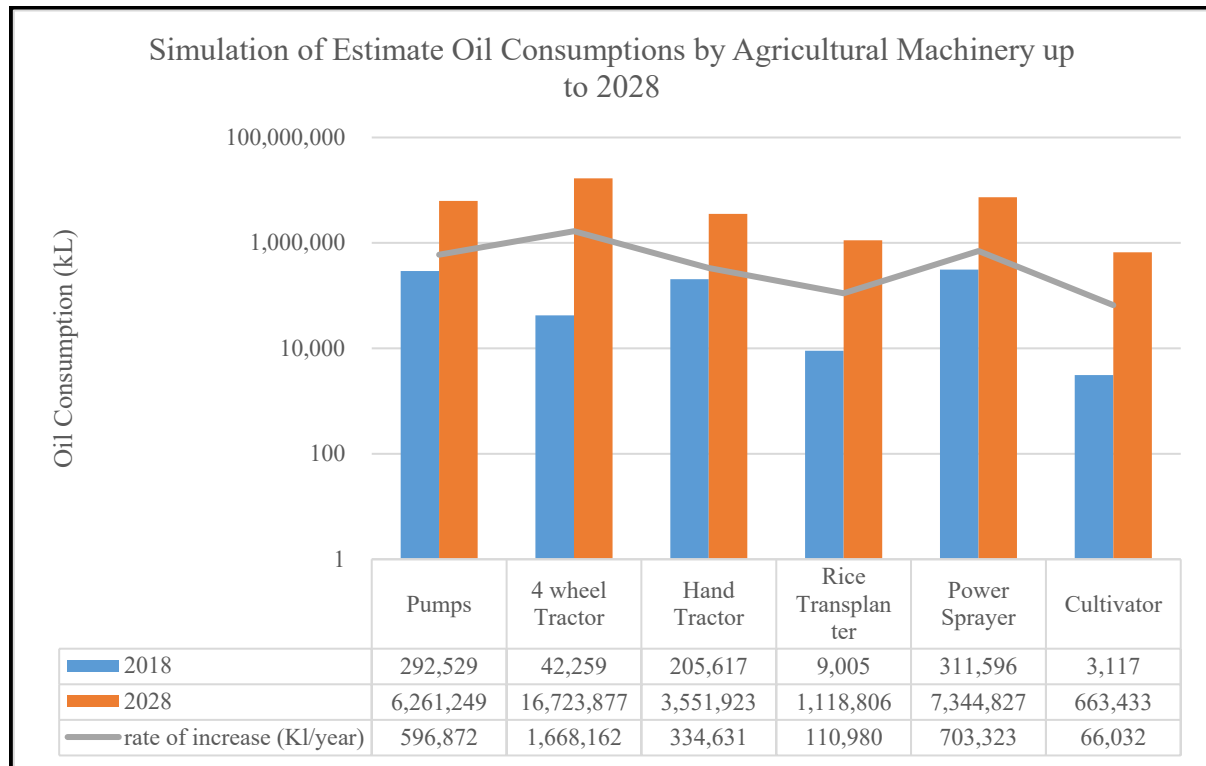


Figure 3. Simulation of oil consumption by on-farm machinery in 2028

4. Renewable Energy Application in Agriculture

Energy sector in agriculture can be directed particularly to contribute the target of renewable energy application in the National Energy Mix Program [4]. At present, several agricultural machinery has been disseminated using renewable energy. After the cut-off kerosene subsidies, the dryer heat energy is obtained from biomass combustion such as rice husk, wood, biomass pellets, corncobs and other biomass sources. Some locations has been introducing photovoltaic (PV) to power the water pumps (Figure 4).



Figure 4. PV to power agricultural pumps

The use of converters on gasoline engines for working in dual fuel (LPG + gasoline) has also been disseminated to power the water pumps (Figure 5). To reduce conflicts with LPG for household needs, LPG allocation for agriculture is needed or in the future it is expected be able to use biogas bottled as an alternative energy.



Figure 5. LPG to fuel pump

In line with the national program to convert palm oil into biodiesel with the target of using B-30 in 2020 and B-40 in 2021 [4], agricultural machinery driven with diesel engines may have contribution to absorb the supply of biodiesel. The presence of mini-fueling stations and biodiesel blending stations can be expected to facilitate the access of biodiesel in rural area. Progressing in the development of B100 (Figure 6), the use of B-100 may be plausible for small diesel engine applications [10]. Semsamran & Suthisripok 2018 [11] reported biodiesel B100 can be efficiently and effectively used as an alternate fuel for small diesel engines, providing that the engines are adequately and effectively lubricated with the proper grade of oil, the oil is changed on a regular schedule, and the cleaning filter and oil filters are regularly cleaned. This maintenance will prevent problems of mechanical durability and reliability and enable the engine to successfully employ biodiesel B100 over the long term.



Figure 6. B100 laboratory testing in hand tractor

5. Remarks

- An approach of energy estimation in agriculture, in particular fuel consumptions of machinery for paddy production, is presented
- This approach may be useful for a prediction of fuel consumption by agricultural sector. At this time, energy consumption by agricultural sector is under the category of 'Other Sub Sectors' together with energy consumption mining and construction subsectors. In field, the fuel for agricultural machinery is usually obtained from supplies of transportation and household sector.
- There could be a correlation of increasing the index of agricultural mechanization to the increase of agricultural production. The mechanization significantly increased the cropping index, productivity, work efficiency and speed up the process of planting and harvesting works.
- This study estimates that the consumption of diesel oil (GasolCN48) by agricultural machinery is approximately 1.5 million kL in 2018. Projecting the index of mechanization reaching 4.61 hp/ha in 2028, the estimate of fuel consumptions will grow exponentially
- The contribution of energy consumption from agricultural sector can be targeted to intensify the renewable energy application. The renewable energy being disseminated are biomass as heating fuel in grain dryers, solar energy to power water pumps, dual fuel (LPG/biogas & gasoline) engines and biodiesel 30% dan biodiesel 100% (B30 to B100) for fueling the agricultural machinery with diesel engine.
- The B100 can be efficiently and effectively used as an alternate fuel for small diesel engines. The presence of mini-fueling stations and biodiesel blending stations can be expected to facilitate the access of biodiesel in rural area.

References

- [1] CNBC_Indonesia, "Kebal Corona, PDB Pertanian Q2-2020 Melesat Saat Pandemi," Aug. 05, 2020.
- [2] Warta Ekonomi, "Riset Bappenas Bukti Efektifitas Belanja Kementan untuk Ekonomi," *Warta Ekonomi*, Aug. 2018.
- [3] K. PPN/Bapenas, "Kajian Pengembangan LEAP dalam Mendukung Perencanaan Energi," Jakarta, 2014. [Online]. Available: https://www.bappenas.go.id/files/9514/7548/1311/Kajian_Pengembangan_Model_Energi_LEAP_2014.pdf.
- [4] National Energy Council, "Indonesia Energy Outlook 2019," 2019. doi: ISSN 2527 3000.
- [5] ICAERD, "ANALISIS KEBIJAKAN : LEVEL MEKANISASI," 2018.
- [6] ICAERD, "Perencanaan Kebutuhan Alat dan Mesin Pertanian," 2019.
- [7] E. Suarna, "ANALISIS KEBUTUHAN ENERGI PADA SEKTOR PERTANIAN DI PROVINSI GORONTALO," Gorontalo, 2000. [Online]. Available: http://www.geocities.ws/markal_bppt/publish/grtalo/grsuar.pdf.
- [8] Pusat Data dan Sistem Informasi Pertanian, "Outlook Komoditas Sektor Pertanian: padi," Jakarta, 2016. doi: ISSN 1907-1507.
- [9] Ministry of Energy and Mineral Resources, "HANDBOOK OF ENERGY & ECONOMIC STATISTICS OF INDONESIA 2018," Jakarta, 2019. doi: ISSN 2528-3464.
- [10] A. Prabowo, U. Budiharti, E. R. Widjaya, S. Triwahyudi, Harsono, and F. L. Trimulyantara, "EVALUASI KINERJA (PERFORMANCE) ALAT MESIN PERTANIAN DAN KENDARAAN BERMESIN DIESEL BERBAHAN BAKAR B100," 2019.
- [11] T. Semsamran and S. Pattawee, "The impact of biodiesel B100 on a small agricultural diesel engine," *Tribol. Int.*, vol. 128, pp. 397–409, 2018.