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Modelling Biodiesel Production of Banking Scheme With Spline Regression

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Abstract

The portion of renewable energy, one of which is biodiesel production in Indonesia, still relatively low due several obstacles, such as the banking financing scheme. Therefore, this research was carried out by involving banking variables, including the banks, third parties fund and Gross Domestic Regional Product of each province to find the best model that affected the rate of biodiesel production in Indonesia. The Spline Regression method was employed here. Modelling the rate of biodiesel production was done by using the knots point method with the smallest GCV Value. Based on the findings, all variables had an influence with a coefficient of determination of 50%, meaning that the model formed was feasible to use in the modelling data patterns. Among these 3 variables, the variable banks had the best influence in determinang tha rate of biodoesel production in each province in Indonesia. In conclusion, the financing scheme from the banking side is an important thing to do considering that the more the number banks in a province, the greater the development potential of biodiesel production from each of these provinces.

Key words : Banking Scheme, Biodiesel Production, Spline Regression

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INTRODUCTION

The Government of the Republic of Indonesia currently has showed its full support for activities to realize renewable resources for fuel, such as biodiesel, bio-oil, bioethanol, biogas and other fuels from natural gas. The liquid fuel market is currently dominated by diesel fuel (Agustina, 2020). The issue of Presidential Regulation No. 79 of 2014 indicated serious efforts in accelerating the use of biofuels in the future. In 2021, the Government confirms that the use of biodiesel is at a level of 30% and is expected to increase by 40% in the following year (IESR, 2021).

With support of the Government Programs regarding the acceleration of biofuel development, it is expected that the programs will provide benefits for Indonesia future through the development of renewable and environmentally friendly fuels and also reduce dependence on imported fuel (Sudjoko, 2021).

Today, solutions are urgently needed to solve the national energy problems. One of which is the need to develop alternative energy that is renewable and based on Indonesia's bio-resources as a means of reducing the high dependence on fossil-based fuels called Biodiesel.

Biodiesel development is in separable from several supporting factors, covering the role of biodiesel as an effort to overcome energy security problems and solutions in reducing import pressures and threats to energy security (Richard, 2016). The development of biodiesel can also improve the economy of the community and regions, both directly and indirectly (Thondhlana, 2014). In addition, an increase in biodiesel production can be an opportunity to connect to international markets with new demands from the energy market (Boonks & Angelica, 2015).

Biodiesel has some advantages, and these made it the best alternative to replace fossil fuels and used in various countries sensitive to environmental issues. Based on the data from the Ministry of Energy and Mineral Resources (ESDM), Indonesia has produced around 16.37 million kiloliters of biodiesel in 2021.

However, the potential of Indonesia's renewable energy has not been managed properly due to its low demand (Ermawati, 2015). The development of biodiesel production provides benefits for the community and regions including creating jobs, generates income for Regional Governments, infrastructure development, reduces dependence on fossil fuels and energy imports and minimizes negative impacts on the environment (Fauzi et al., 2019). The cause of low biodiesel production is heavily influenced by political economy and price factors (Nuva, 2019).

The data from the Statistics Indonesia (2022) show that in 2015 the share of renewable energy was still very low and only reached 4.9% of the National energy mix and has not experienced a significant increase because it only increased to 12.16% in 2021. One of the causes was financing and unfavorable investment climate. (ESTA, 2015). According to Rafian Joni et al (2020) the development of biodiesel made from palm oil is influenced by bank interest rates where every 10% increase in interest rates will have an impact on the palm oil industry by 1.53%. In addition, biodiesel production that has not met the production target requires efforts to increase investment in the biodiesel sector, especially in the process of production, processing and distribution (Elisha et al., 2019).

As an effort to increase the role of banking in encouraging sustainable financing practices, support from stakeholders is needed (OJK, 2019). Banking has an important role in preparing financing that is based on sustainable finance principles to support the development of biofuel production, namely biodiesel.

Studies related to biodiesel production and its factors have been carried out by previous researchers, both qualitatively and quantitatively. Therefore, this study used a non-parametric method with a spline model to investigate the factors thought to influence the rate of biodiesel production in Indonesia.

Regarding the previous description, this study focused on the rate of total biodiesel production in several provinces in Indonesia. Here, the factors that influenced the level of total biodiesel production from a bank financing standpoint were investigated. By doing so, it was hoped that policy holders can use the findings of this study as an effort to improve financing schemes for biodiesel production and a reference to improve Indonesia's economy.

Some studies have actually showed that banking access has a negative impact on economic growth (OJK, 2019). Arcand et al (2012) and Samargandi (2015) show that increasing credit can only encourage economic growth at a certain level and if it is too large it can actually reduce economic growth because of a productivity shift effect from the real sector to the financial sector. Hence, it is necessary to examine the relationship between banking access and GRDP as a representative of economic growth on the rate of biodiesel production in Indonesia.

This study used the spline regression to model the growth of biodiesel production in terms of banking financing standpoint. The spline regression method performs well at modeling data that have a changing pattern at certain sub-intervals (Nyoman & Elfrida, 2013). It is a model that has statistical and visual interpretation and excellent ability to generalize complicated and complex statistical modeling (Alwi et al., 2021).

METHOD

This study used a nonparametric regression method to determine the relationship pattern between response variables and predictor variables with unknown regression function curves. Its equation model is generally illustrated as follows (Mughni et al., 2020).

$$y_i = f(t_i) + \varepsilon_i, i = 1,2,\ldots,n \quad (1)$$

Spline is one of the nonparametric regression model approaches which is polynomial, segmented and has flexible properties. It has a dependency on the knots point, a point of integration together with the behavior change pattern of the function at different intervals (Merdekawati & Budiantoro, 2013)

The function G in a spline space in the orde m with a knot point of k1, k2, ..., kj is expressed by the following equation.

$$G(x_i) = \sum_{j=0}^{m} \beta_j x_i^j + \sum_{k=1}^{j} \beta_{k+m}(x_i + K_k)_+^m \quad (2)$$

In the above equation, β is a model parameter with m as the spline orde (Nyoman & Elfrida, 2013). The estimation of the spline model parameters is as follows.

$$y_i = G(x_i) + \varepsilon_i \quad (3)$$

The best spline estimator is obtained by looking at the optimal knot point. The knot point is the joint point and has a change in the behavior pattern of the curve and function. Most knot points are obtained by the Generalized Cross validation (GCV) method.

In parameter testing, there are several stages to find out the predictor variables that have a real relationship with the response variable. The stages of testing firstly cover the simultaneous test to know whether the regression parameters are significant simultaneously or not. Secondly, the statistical test by using the F test is performed. Thirdly, an individual test is carried out to determine which variables are significant individually. The test statistic used is the t test.

Furthermore, the data used in the Spline regression have to be decided to meet the residual assumptions or not. Meanwhile, the assumption testing must meet the assumptions of identical residue, be independent, and have normally distributed data (Alwi et al., 2021). The data used in this study were secondary data obtained from the Ministry of Energy and Mineral Resources in 2022, Indonesian Banking Statistics by OJK in 2022 and Statistics Indonesia in 2022. In addition, the research units observed were 34 provinces throughout Indonesia.

The variables in this study were the amount of biodiesel production produced by each province (Y), the number of banks for each province (X1), the amount of Third Party Funds (DPK) for each province (X2) and the GRDP of each province (X3).

Data collection techniques were done using a library research approach, namely collecting data by reviewing various journals related to research various types of publications considered relevant to the topic, focused and having similar variables to obtain the necessary information and data.

The operational definitions of the variables in this study can be seen in Table 1 below

.**Table 1.** Variable Operational Definitions in 2021

Variable	Operational Defition	Data Source
Amount of biodiesel production	Amount of biodiesel produced	Ministry of Energy and Mineral Resources (ESDM)
Number of banks	Numbers of operating banks	Indonesia banking statistics from Financial service authority (OJK)
DPK	Number of savings of people managed by banks	
GRDP	Contribution of economic growth value	Statistics Indonesia

Some procedures were carried out in the analysis of data, including analyzing descriptive statistics to find out the characteristics of each variable in the research unit, modeling the rate of biodiesel production in Indonesia with its predictor variables, choosing the most optimal knot point based on the lowest GCV value, modeling the rate of biodiesel production using a spline with the most optimal knot point, testing the best residual assumptions of the spline model, calculating the value of the coefficient of determination and making interpretations based on the results of the analysis and the spline model formed.

RESULTS AND DISCUSSION

The characteristics of the biodiesel production growth and its influencing factors are presented in Table 2.

The optimal knot point selection was done by finding the lowest GCV value generated using 1 knot point, 2 knot point and 3 knot point. The results are showed in Table 3.

Table 2. Biodiesel Production Growth Characteristics and Factors Assumed to Influenced it in 2021

Variable	Average	Minimum	Maximum
Y	482670	0	5100000
X1	105.62	16.00	456.00
X2	216552	5936	3841292
X3	4.178	-2.470	16.400

Source: ESDM, SPI PJK & BPS (Processed)

Table 3. GCV Value of Each Knot in 2021

No	Knot	GCV Value
1	1 knot point	$1.075152e^{12}$
2	2 knot point	$9.77806e^{11}$
3	3 knot point	$9.451096e^{11}$

Source: Variable (processed)

Based on the above table 3, the minimum GCV value generated when using 3 knot points was 9.45102e11.

The minimum GCV value of the GCV values using 1 knot point, 2 knot point and 3 knot point produced a value of 2 knot point. The modeling the rate of biodiesel production using the optimal knot point, which was 3 knot points, is showed in the following equation.

$$\hat{y} = -97{,}652519 - 911{,}115376x_1 + 1344{,}109160(x_1 + 33{,}95918) + 1806{,}073581(x_1 + 78{,}85714) + 2115{,}142634(x_1 + 393{,}14286) + 3{,}882027x_2 + 23{,}985271(x_2 + 162481{,}1) - 56{,}791144(x_2 + 553844) + 28{,}405826(x_2 + 3293384) - 916{,}767592x_3 - 1117{,}011388(x_3 - 1{,}699796) - 1076{,}053461\ (x_3 + 0{,}2257143) - 1035{,}095535\ (x_3 + 13{,}7042857) \quad (1)$$

There were two parameter estimation tests carried out, namely the simultaneous test and the individual test. The results of the simultaneous parameter estimation test can be seen in Table 4 below.

Table 4. The Simultaneous Parameter Test of the Variables in 2021

Variation Source	df	SS	MS	F	P Value
Regression	12	11024497069	9187080	1.75	0.0126
Error	21	11024497069	524976		
Total	33	22048994138			

Based on Table 4, the statistical value of the F test was 1.75 with a p-value of 0.0126. When compared with the significance level of 0.05, it can be concluded that the decision taken was to reject H_0. It meant that there was at least one variable that had a significant influence on the model formed. This rejection indicated the need to do individual tests to find out which variables had a significant influence on the model. The test results are presented in Table 5 below.

Table 5. Individual Test in 2021

Variabel	Parameter	Estimator	$T_{statistic}$	P Value
Konstan	β0	-97.652	-9.978	2.012^{-09}
X1	β1	-911.115	-4.534	0.00180
	β2	1344.109	38.229	$6.703e^{-21}$
	β3	1806.073	23.524	$1.427e^{-16}$
	β4	2115.142	19.669	$5.233e-^{15}$
X2	β5	3.882	16.775	$1.221e^{-13}$
	β6	23.985	34.251	$6.54e^{-20}$
	β7	-56.791	-58.231	$1.055e^{-24}$
	β8	28.405	58.527	$9.501e^{-25}$
X3	β9	-916.767	-9.961	$2.072e^{-9}$
	β10	-1117.011	-9.965	$2.059e^{-9}$
	β11	-1076.053	-9.965	$2.059e^{-9}$
	β12	-1035.095	-9.96	$2.059e^{-9}$

Source: Variable Data (Processed)

Table 5 shows that all parameters produceed an indicator P-value less than the significance value used, namely 0.05, so all these variables had a significant influence on the model.

The coefficient of determination (R^2) shows how good the model is in explaining the rate of biodiesel production in Indonesia.

$$R^2 = \frac{SS_{regresi}}{SS_{Total}} x100\% = \frac{11024497069}{22048994138} x100 = 50\% \quad (2)$$

Since the R^2 value obtained was 50%, the existing variables were able to explain 50% of the variation in the variable rate of biodiesel production in Indonesia, while the rest was explained by other variables that have not been studied.

The coefficient of determination value of 50% shows that the model formed was feasible to use in modeling data patterns.

After testing the Spline regression model and meeting all residual assumptions, the researchers finally found 3 variables that affected the rate of biodiesel production in Indonesia, namely the number of banks, total DPK and GRDP in each provincial unit in Indonesia. The interpretation of each significant variable is explained as follows: (a) If X_2 and X_3 were considered constant, the variable equation model of the number of banks (X_1) on the rate of biodiesel production in Indonesia is as follows.

$$\hat{y} = 911{,}115376x_1 + 1344{,}109160(x_1 + 33{,}95918) + 1806{,}073581(x_1 + 78{,}85714) + 2115{,}142634(x_1 + 393{,}14286)$$

$$= \begin{cases} 911{,}115376 \; ; \; x_1 < 33{,}95918 \\ 2255{,}224536 \; ; \; 33{,}95918 \le x_1 < 78{,}85714 \\ 4061{,}298117 \; ; \; 78{,}85714 \le x_1 < 393{,}14286 \\ 6176{,}440751 \; ; \; x_1 > 393{,}14286 \end{cases} \quad (3)$$

In the above equation, there are 4 intervals on each Spline piece. It meant that if provinces with a number of banks less than 33.95918 got an increase by 1%, the biodiesel production in those provinces tended to increase by 911.115376%. The provinces included in this region were in interval I. If province with a number of banks between 33.95918 and 78.85714 got an increase by 1%, their biodiesel production tended to increase by 225 5.224536%. The provinces included in this region were in interval II. If province with a number of banks between 78.85714 and 393.14286 got an increase by 1%, their biodiesel production tended to increase by 4061.298117%. The provinces included in this region were in interval III. Then, if provinces with a number of banks greater than 393.14286 got an increase by 1%, their biodiesel production tended to increase by 6176.440751%. The provinces included in this region were in interval IV. In details, the provinces in each interval are listed in table 6 below.

Table 6. Provinces in Interval I – IV in terms of Number of Banks

Interval	Province
Interval I	Bangka Belitung, North Kalimantan, West Sulawesi, Gorontalo, North Maluku, West Papua
Interval II	Aceh, Bengkulu, Riau Islands, Jambi, Lampung, Yogyakarta, East Nusa Tenggara, West Nusa Tenggara, Central Kalimantan, South Kalimantan, Southeast Sulawesi, Central Sulawesi Tengah, North Sulawesi, Maluku, Papua

Interval	Province
Interval III	North Sumatera, South Sumatera, West Sumatera, Riau, Banten, Central Java, Bali, West Kalimantan, East Kalimantan, South Sulawesi
Interval IV	DKI Jakarta, West Java, East Java

(b) If X1 and X3 were considered constant, the equation model of the DPK variable (X2) on the rate of biodiesel production in Indonesia is as follows.

$$\hat{y} = 3{,}882027x_2 + 23{,}985271(x_2 + 162481{,}1) - 56{,}791144(x_2 + 553844) + 28{,}405826(x_2 + 3293384)$$
$$= \begin{cases} 3{,}882027\ ;\ x_2 < 162481{,}1 \\ 27{,}867298\ ;\ 162481{,}1 \le x_2 < 553844 \\ -28{,}923846\ ;\ 553844 \le x_2 < 3293384 \\ -0{,}51802\ ;\ x_2 > 3293384 \end{cases} \quad (4)$$

There were 4 intervals on each spline piece presented by the above equation. Based on the equation, if provinces with DPK less than 162,481.1 got an increase by 1%, the biodiesel production in those provinces tended to increase by 3.882025%. Those included in this region were in interval I. If provinces with total DPK between 162,481 to 553,844 got an increase by 1%, their biodiesel production tended to increase by 27.867298%. The provinces included in this region were in interval II. If provinces with a total DPK between 553,844 and 3,293,384 got an increase by 1%, their biodiesel production tended to decrease by 28.923846%. The provinces included in this region were in interval III. Then, if province with a total DPK greater than 393.14286 got an increase by 1%, their biodiesel production tended to decrease by 0.51802%. The provinces included in this region were in interval IV. Further details of the intervals are presented in the following table 7.

(c) If X1 and X2 were considered constant, the GDRP variable equation model (X3) on the rate of biodiesel production in Indo-nesia is as follows.

$$\hat{y} = -916{,}767592x_3 - 1117{,}011388(x_3 - 1{,}699796) - 1076{,}053461(x_3 + 0{,}2257143) - 1035{,}095535(x_3 + 13{,}7042857)$$
$$= \begin{cases} -916{,}767592\ ;\ x_3 < -1{,}699796 \\ -2033{,}77898\ ;\ -1{,}699796 \le x_3 < 0{,}2257143 \\ -3109{,}832441\ ;\ 0{,}2257143 \le x_3 < 13{,}7042857 \\ -4144{,}927976\ ;\ x_3 > 13{,}7042857 \end{cases} \quad (5)$$

In the above equation, there are 4 intervals on each Spline piece. Regarding this model, if provinces with a GRDP of less than -1.699796 got an increase by 1%, their biodiesel production tended to decrease by 916.76759 2%. The provinces included in this region we-re in interval I. If provinces with a GRDP bet-ween -1.699796 to 0.2257143 got an increase by 1%, their biodiesel production tended to decrease by 2033.77989%. The provinces included in this region were in interval II. If provinces with a GRDP between 0.2257143 and 13.7042857 got an increase by 1%, their biodiesel production tended to decrease by 3109.832441%. The provinces incl-uded in this region were in interval III. In addition, if province with a GRDP greater than 13.704 2857 got an increase by 1%, their biodiesel prod-uction tended to decrease by 4144.927976%. The provinces included in this region were listed in interval IV. Further details of interval catego-rization are in the following table 8.

Table 7. Provinces in Interval I-IV in terms of DPK

Interval	Province
Interval I	Aceh, South Sumatera, West Sumatera, Bengkulu, Riau, Riau Islands, Jambi, Lampung, Bangka Belitung, Yogyakarta, Bali, East Nusa Tenggara, West Nusa Tenggara, West Kalimantan, East Kalimantan, Central Kalimantan, South Kalimantan, North Kalimantan, South Sulawesi, Southeast Sulawesi, West Sulawesi, Central Sulawesi, North Sulawesi, Gorontalo, North Maluku, Maluku, West Papua, Papua
Interval II	North Sumatera, Banten, West Java, Central Java, East Java
Interval III	-
Interval IV	DKI Jakarta

Source: Data of Each Variable (processed)

Table 8. Provinces in Interval I-IV in terms of GRDP Variable

Interval	Province
Interval I	Bali
Interval II	West Papua
Interval III	Aceh, North Sumatera, South Sumatera, West Sumatera, Bengkulu, Riau, Riau Islands, Jambi, Lampung, Bangka Belitung, Banten, DKI Jakarta, West Java, Central Java, Yogyakarta, East Java, East Nusa Tenggata, West Nusa Tenggara, West Kalimantan, East Kalimantan, Central Kalimantan, South Kalimantan, North Kalimantan, South Sulawesi, Southeast Sulawesi, West Sulawesi, Central Sulawesi, Gorontalo, Maluku
Interval IV	North Maluku, Papua

Source: Data of Each Variable (processed).

Based on the analysis results, the previously discussed three variables had a significant effect on biodiesel production in Indonesia. The Spline regression results showed that the number of banks in each province in Indonesia contributed the greatest contribution and influenced in increasing the rate of biodiesel production in Indonesia. In fact, the provinces of DKI Jakarta, West Java and East Java were potential to increases the production in Indonesia. This meant that if the provinces could provide access to financing and produce biodiesel, the biodiesel production could increase by 6176.44%.

The above results are in accordance with a study by Rafian Joni et al (2020) that access to banks in the form of interest rates can develop biodiesel due to the possibility of area expansion and an access to banking and investment.

The role of banking in encouraging sustainable credit practices has indeed become the goal of current policy makers. Therefore, it is necessary to have an understanding of banks in assisting business activities and the biodiesel production industry in Indonesia to minimize risks in lending. Similarly, the DPK variable also provided a good contribution to increasing biodiesel production in Indonesia. Theoretically, the greater the value of a bank's TPF, the greater the value of bank credit access.

The GRDP variable surprisingly gave different results. When the GRDP value increased, the biodiesel production tended to decrease. It was assumed that this happened because it was not GRDP that affected biodiesel production, but biodiesel production that affected the increase in GRDP of a region. It is in accordance with Deni Ismail's study (2022) which concludes that the biodiesel production variable can have a positive influence on economic growth in Indonesia.

CONCLUSION

Based on the results of data analysis and models, it is known that all variables have a significant effect indicated by a coefficient of determination of 50%. Among the 3 variables, the number of banks has the best influence on the biodiesel production process in each prov-ince. In other words, if there are more banks in each province, it will increase biodiesel pr-oduction through banking financing schemes, especially for the provinces in interval IV area, such as DKI Jakarta, West Java and East Java.

The sustainability of biodiesel product-ion, both in provinces that have and have not yet produced it will be able to be increased if banking in Indonesia and each province faci-litates financing schemes for biodiesel prod-uction. Coupled with strong, appropriate and coherence policies from the Government, sustainable and increasing biodiesel produc-tion growth can be achieved.

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REFERENCES

Agustina, P. A. (2020). *Analisis Pengaruh Produksi dan Nilai Tukar Rupiah Terh-adap Ekspor Komoditas Minyak Kela-pa Sawit (CPO) 1988 - 2018. In Skripsi.* UIN Syarif Hidayatullah:Jakarta.

Alwi, W., Irwan, M., & Musfirah. (2021). *Pen-erapan Regresi Nonparametrik Spline Dalam Memodelkan Faktor-Faktor Yang Mempengaruhi Indeks Pemba-ngunan Manusia (IPM) di Indonesia Tahun 2018. Jurnal Matematika dan Statistika Serta Terapannya*, *9*(112–119).

Boonks, F., & Angelica, M. (2015). Constructing Sustainable Palm Oil: How Actors Defi-ne Sustainability. *Journal of Cleaner Pr-oduction*, *18*, 1685–19.

Elisha, O., Akhmad, F., & Anggraini, E. (2019). *Analisis Produksi dan Konsumsi Biofuel Minyak Sawit dan dampaknya Pada Emisi CO2* (Studi kasus Indonesia). *Scientific Repository*.

Ermawati, T. (2015). *Analisis Subsidi Energi Dal-am Pengembangan Energi Terbarukan. Jurnal Ekonomi Dan Pembangunan*, *23*(1).

Esta, L. (2015). *Mendorong Pengurangan Emisi Melalui Pembiayaan Energi Terbarukan di Indonesia. Jurnal Ekonomi Dan Pemb-angunan*, *23*(1).

Fauzi, A., Nuva, Dharmawan, A., & Putri, E. I. (2019). Political Economy of Renewable Energy and Regional Development: Understanding Social and Economic Problems of Biodiesel Development in Indonesia. *Jurnal Sosiologi Pedesaan*.

IESR. (2021). *Indonesia Energy Transition Out-look 2021: Tracking Progress of Energy for Essential Services Reform (IESR)*.

Merdekawati, I., & Budiantoro, N. (2013). *Pem-odelan Regresi Spline Truncated Multi-variabel pada Faktor-Faktor yang Mem-*

pengaruhi Kemiskinan di Kabupaten/ Kota Provinsi Jawa Tengah. Jurnal SAINS Dan Seni ITS, *2*(1), 19–24.

Mughni, Fadly, M., Adnan, A., & Horison. (2020). *Pemodelan Tingkat Pengangguran Terbuka di Pulau Sumatera Dengan Menggunakan Regresi Nonparametrik Spline. Jurnal Sains Matematika Dan Statistika*, *6*(1).

Nuva. (2019). *Ekonomi Politik Energi Terbarukan dan Pengembangan Wilayah: Per-soalan Pengembangan Biodiesel di Indo-nesia. Jurnal Sosiologi Pedesaan*, 110–118.

Nyoman, B., & Elfrida, K. (2013). *Pendekatan Regresi Nonparametrik Spline Untuk Pemodelan Laju Pertumbuhan Ekonomi (LPE) di Jawa Timur. Jurnal Sains Dan Seni POMITS*, *2*(2), 2337–3520.

OJK. (2019). *Kredit/ Pembiayaan Perkebunan dan Industri Kelapa Sawit*.

Richard, D. (2016). Challenges and Policies in Energy Sector. *Energy Policy*, *9*(8), 513–519.

Sudjoko, C. (2021). *Pengembangan Biofuel Berbasis Crude Palm Oil (CPO) Dalam Mendukung Target Ketahanan Energi Security and Defense Appliances. Jurnal Ketahanan Energi, 8*(11), 81–96.

Thondhlana, G. (2014). *The Local Livelihood Implications of Biofuel Development and Land Acquisitions ins Zimbabwe*. *11 : Ontar.*