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Potential Biodiesel Production from Rice Bran Oil in Nigeria: A Synergy of B-20 Diesel Blend Policy and Rice Importation Ban

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Abstract

In an attempt to meet the sustainable development goals (SDG)s and a synergy on two government policies (ban on rice importation and B-20 policy for diesel blend with biodiesel) to boost energy production in Nigeria, rice bran has been examined as a potential feedstock for the production of standard biodiesel. Rice bran biodiesel has been found to be a promising sustainable fuel capable of meeting heavy-duty energy demands of the emerging net-zero carbon economy. However, one major setback that could affect the massive deployment and commercialization of biodiesel is the sustainable availability of efficient and effective feedstock needed for biodiesel production. This paper extensively explores the potential of biodiesel production from rice bran, a sustainable, available biowaste material in Nigeria. With the assumption that the demand for rice in Nigeria is satisfied by local production in line with the ban on rice importation, an average of 47,048 metric tons of rice bran biodiesel can be produced annually. With the continuous increase in population and consequent rice consumption, biodiesel from rice bran has been established to soon meet the demand on biodiesel for B-20 policy in Nigeria. This again will significantly aid in meeting SDG 7 (affordable and clean energy) and SDG 11 (Sustainable cities and environment).

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1. Introduction

Energy has evolved to become one of the most crucial needs of the 21st century. The past decades have seen energy become one of the major prime movers of the global economy. Generally, the development of world economies is hinged on the availability and utilization of energy resources [1]. In recent years, the rapid surge in the global human population, which is currently pegged at approximately 7 billion with a yearly growth rate of 5% [2], has necessitated an increase in the demand for energy [3]. Over the past few decades, energy from fossil fuel sources has been used to meet the energy demands of the world. However, the utilization of fossil fuels for energy generation, has been found to be unsustainable and detrimental to the environment [4]. Typically, when combusted, fossil fuels release carbon dioxide and other toxic gases to the atmosphere. This additional carbon dioxide released into the atmosphere has been found to be a major contributor to climate change, and ultimately global warming [4].

Lately, the call to produce fuels that are both sustainable and environmentally friendly, makes biofuels a preferred alternative source of energy [5]. Biofuels, which are fuels obtained from biomass have been found to be sustainable alternatives to fossil fuels. Biodiesel which is an important type of biofuel is gaining acceptance in the global market as a fuel that is environmentally friendly and capable of generating the energy needed for heavy-duty operations. However, a major setback in the commercialization of biodiesel is the choice of efficient, effective, quality and readily available feedstock.

Rice bran, an agricultural waste from rice milling has been found to be a good feedstock for biodiesel production [6]. Rice bran, which is a non-edible material, does not directly serve as food for humans and animals, and as a result, it mostly ends up being wasted or used in the production of low-cost products [7]. Its use as feedstock for biodiesel production will not only distract attention from the use of edible feedstock, but would also encourage the production of food for humans and animals through the cultivation of rice. With the high consumption of rice in the nation, and the Nigerian government ban on the importation of rice as at 2015 [8], it simply implies that the demand for rice will be met locally, and it will lead to a huge production of rice bran.
Presently, the sole reliance on clean fuels cannot meet the global demand for energy, as such, the phased transition from fossil fuel energy to renewable energy becomes the necessary line of action. [9]. One policy that has been drafted to ease the transition from fossil fuel to cleaner fuels is the 20% biodiesel blend policy, also known as the B-20 policy [10]. This policy aims to ensure a 20% biodiesel blend for every fossil fuel diesel consumed. In doing this, there would be a 20% reduction in diesel consumption, ultimately reducing carbon emission from biodiesel combustion by 20%. Since its inception, the B20 policy in Nigeria has refused to be fully enacted. One may argue that this is one of the ambiguous targets of the federal government that has largely been unmet. For this policy to be met, the government must utilize readily available renewable and sustainable feedstock from waste materials for biodiesel production. This study therefore aims to quantitatively examine the prospective potential of producing biodiesel from rice bran oil in Nigeria in meeting the B20 policy demand for biodiesel

1.2. Overview of rice bran

1.2.1. Rice bran

There are different potential feedstocks for biodiesel production. The use of edible vegetable oils or the first-generation feedstocks has remained a potential feedstock for the production of biodiesel. Generally, biodiesel feed-stocks can be classified thus, edible vegetable oil, non-edible vegetable oil, Waste or recycled oil, Animal fats [11]. Currently, over 95% of biodiesel produced globally uses edible vegetable oil which is readily available in a large scale as feedstock. Recently, great concern has been raised since the competition of these edible oils as a food source and as fuel feedstock makes it a non-ideal feedstock for fuel production [12, 13]. Also, this argument says using edible oil as feedstock may result in starvation, particularly in the developing countries as well as other environmental associated problems such as utilizing much of the available arable land for their cultivation, deforestation, damage to wildlife etc. [14]. These problems can create serious ecological imbalances as countries around the world began cutting down forests for plantation purposes. Therefore, the effort on using second-generation or non-edible oil sources has gained much attention. Examples of such feedstocks include Jatropha curcas, Pongamia glabra (koroch seed), Linseed, Pongamia pinnata (karanja), Hevea brasiliensis (Rubber seed), rice bran etc [14, 15].

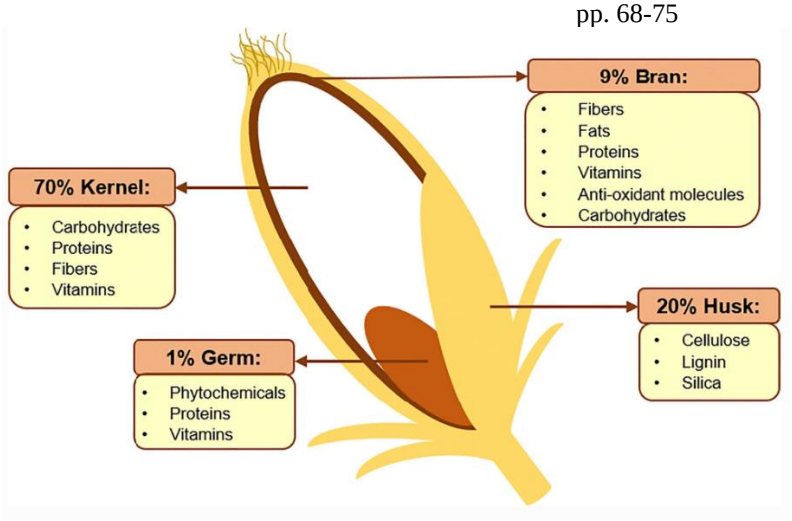

Figure 1: component of harvested rice [16]

Rice production is a renewable process so its availability as feedstock for biodiesel production is renewable in nature. Husk, bran, and broken rice are the by-products of the rice milling industries which can be put into better and profitable use both industrially and for feed purposes [17]. Of these by-products rice bran is the most valuable, it is obtained from the outer layers of the brown rice during milling, and it consists of the pericarp, aleurone layer, germ, and a part of the endosperm. Over the years rice bran has become a potential source of vegetable oil, feed, and fertilizers [18]. Rice consumption in Nigeria as reported by the World Rice Statistics of IRRI stood over 6 million tons in 2017 [19].

1.2.2. Contents of Rice bran

Rice bran contains several fractions which include essential fatty acids, proteins, fibers, minerals (such as iron, phosphorus, and magnesium), vitamins, antioxidants (e.g γ-oryzanol), and other micronutrients. Table 1 shows the percentage composition of oil in rice bran as reported by different authors.

TABLE 1: Percentage Lipid/Oil content in Rice bran as given by various authors

S/NO	% Lipid/Oil Content	Reference
1.	17 - 24	[20]
2.	15-23	[21]
3	15.3	[22]
4	16 - 20	[23]
5	16 - 32	[24]

2. Methodology

In executing this study, a ten-year data of AGO sales published by the Nigerian National Petroleum Corporation (see Figure 1) was obtained and analysed. Also, data of rice production for ten years as presented by the national agriculture commission (Figure 2), was obtained and the amount of rice bran produced per year was estimated by computational analysis. These data set were used to estimate the potential fraction biodiesel from rice bran could provide for the implementation of the B-20 (20% blend of fossil diesel with biodiesel) policy.

Bran is one of the three main by-products of rice milling and Table 1 shows different percentage oil content of rice bran as reported by various authors and under optimized conditions, Chen et al., (2013) achieved a 99.5% conversion using a catalyst made from rice husk. So, in an attempt to estimate the amount of RBB that can be produced locally in Nigeria using rice bran as feedstock, we assume a 17% yield on oil (as shown in Table 1) and a 90% conversion of oil to biodiesel (adopted from [25]).

3. Results and Discussion

3.1. Demand for diesel fuel in Nigeria

The demand for diesel in Nigeria is currently met wholly from fossils. This demand has varied over the years as a result of several factors ranging from availability, pricing, electrical power supply and economic stability. From a ten-year domestic consumption data of fossil fuel (shown in Figure 1) as published by the Nigerian National Petroleum Corporation (NNPC), it can be seen that AGO is still very much in high demand, with the highest demand of 1750465MT recorded in 2011 and the lowest recorded in 2015. This drop in the demand of diesel could be attributed to the 2015 general elections in Nigeria that led to the arrival of a new government. However, from the trends, the demand of diesel increased in the following year to 664,903MT, and in the next consecutive years to 1,291,770MT and 1,017,689MT respectively. This growing demand of biodiesel ultimately leads to a growing rise in carbon emission. To tackle this rise in emission, the need to implement the B20 policy becomes one of urgent priority. From figure 1, the declining trend for diesel demand could be attributed to factors such as economic crisis.

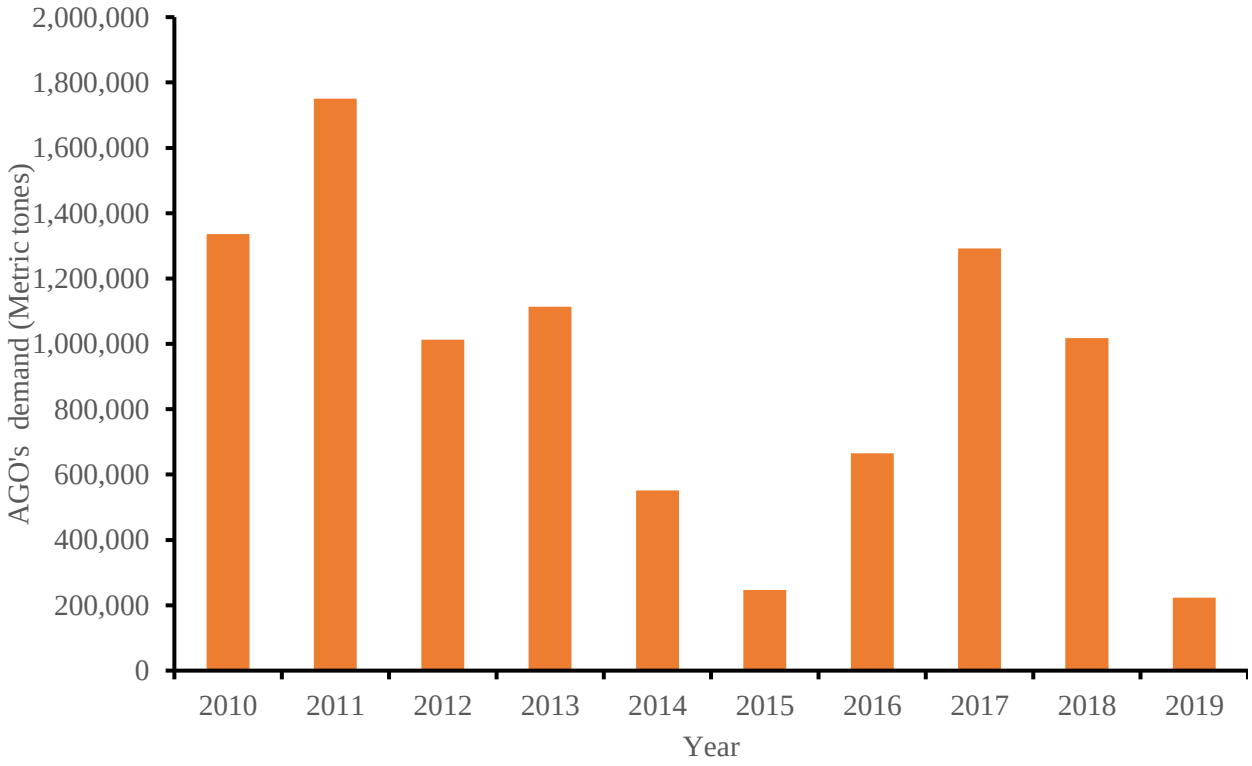

Figure 1: A ten-year Rice demand and AGO's domestic product sales in Nigeria. [Source: [26]]

3.2. Rice consumption in Nigeria

Rice consumption in Nigeria currently stands at over 9 million metric tons (MMT) per annum. In order to meet this demand, locally milled rice stands at about 5.5 MMT accounting for approximately 57 percent of total supply of rice in Nigeria, with the remaining 43 percent being bridged through imports [19, 27]. With this consumption rate, an estimated capacity of 1.02 MMT of oil and 0.92 MMT of biodiesel can be produced annually (assuming 17% oil content and conversion of oil to biodiesel 90%) if all our consumed rice are locally produced. From the data presented in Figure 1, an average 184198 MT (0.184 MMT) of biodiesel is required for the implementation of the B-20 policy, so the biodiesel production rate will be expected to meet this biodiesel required for blending with petroleum diesel in accordance with B-20 policy.

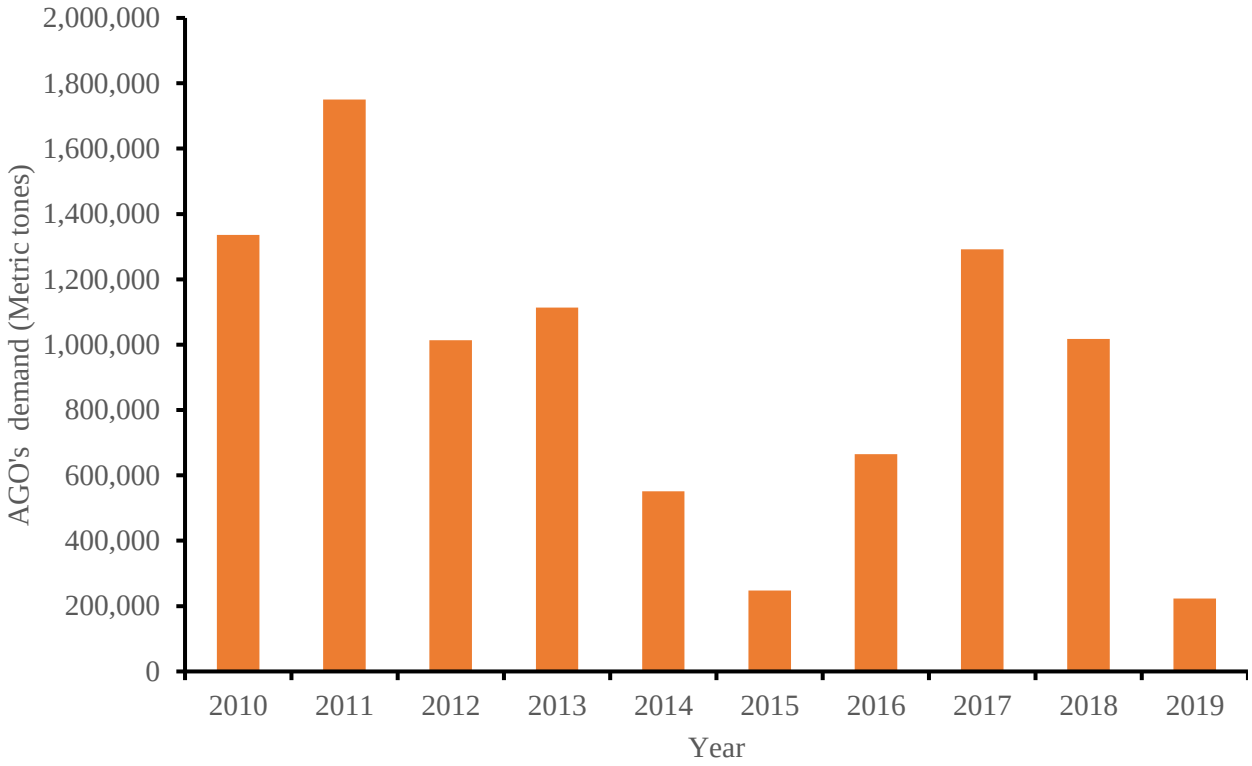

Figure 2: A ten-year domestic demand for rice in Nigeria [Source: [28]]

On comparing Figure 1 and Figure 2, there is a higher growth rate in rice consumption than in diesel, this indicates a positive in the possibility of rice bran efficiently meeting the B-20 policy need.

3.3. Estimated rice bran biodiesel (RBB) production

The estimated rice bran biodiesel and the amount of biodiesel required to implement the B-20 policy are presented in Table 2. Figure 3 shows the percentage fraction of biodiesel required that is being provided by RBB. At present, an average of 47,048 metric tons of rice bran biodiesel can be produced annually. From Figure 3, the trendline (broken line) shows an upward trend of RBB to completely meet the needed amount of biodiesel. By a way of correlation, there is a significant positive relationship between rice consumption and its ability to meet the biodiesel requirement for the B-20 policy. The diesel demand (Figure 2), rice consumption (Figure 1), and the trendline in Figure 3 all these points to the fact that there is an increase in rice consumption with a corresponding decrease in diesel demand in Nigeria. The increase in rice consumption certainly implies more rice bran generation with improved local milling capacity and a consequent higher yield on RBB.

Overall, this will help to foster the SDGs 7 (affordable and clean energy) and 11 (Sustainable cities and communities) for a safer and more sustainable environment.

Table 2: An estimation of diesel required for 20% blending supplied by RBB in Nigeria

Market year	Biodiesel 90% conversion of RBO	Biodiesel needed (20% of AGO)
2010	43,199,978	267272200
2011	50,399,975	350093000
2012	51,299,974	202644600
2013	52,199,974	222661000
2014	54,899,973	110267600
2015	57,599,971	49437800
2016	60,299,970	132980600
2017	60,749,970	258354000
2018	61,199,969	203537800
2019	61,649,969	44726800

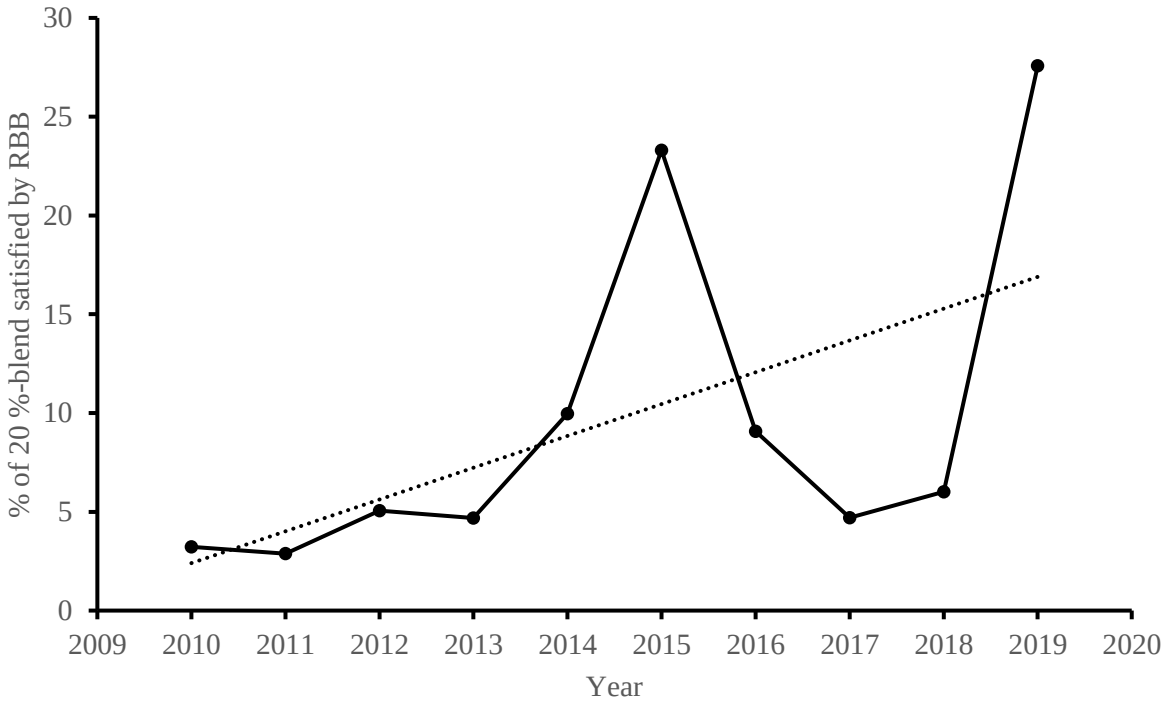

Figure 3: Percentage fraction of biodiesel required for B-20 policy satisfied by RBB

According to World Atlas [29], no barrel of biodiesel was produced in Nigeria for the year 2019, this simply indicates significant economic loss by not engaging the potential biodiesel presents, particularly biodiesel from rice bran which will certainly encourage food production. Adewuyi [30] identified a number of challenges such as land tenure system, high cost of production, poorly enforced governmental policies, competition between biofuel feedstock and food, biotechnology and availability of resources. He however recommended subsidies and government interventions to

mitigate the impact of these challenges so as to foster biodiesel production. This study simply presents a solution to the challenge of competition between biodiesel feedstock and food, it furthermore provides a basis for government/policymakers to see the opportunities inherent in producing biodiesel from rice production in enhancing food production.

4. Conclusion

With a view to ensuring the SDGs and a synergy on two government government policies (ban on rice importation and B-20 policy for diesel blend with biodiesel) to boost energy production in Nigeria, rice bran has been examined as a potential feedstock for the production of standard biodiesel. A ten-year data of diesel from fossil source demand and rice consumption in Nigeria have been analysed to show their trend over the period. The potential of biodiesel from rice bran in meeting the B-20 policy requirement through the adoption of biodiesel from rice bran oil has been established with a current potential of 47,048 metric tons of rice bran biodiesel production annually. This again will significantly aid in meeting SDG 7 (affordable and clean energy) and SDG 11 (Sustainable cities and environment).

Nomenclature

AGO	Automotive gas oil
MT	Metric Tons
MMT	Million Metric Tons
NNPC	Nigeria National Petroleum Corporation
RBB	rice bran biodiesel
SDG	Sustainable Development Goal

References

[1] Brockway, P. E., S. Sorrell, G. Semieniuk, M. K. Heun, V. J. R. Court and s. e. reviews (2021). Energy efficiency and economy-wide rebound effects: A review of the evidence and its implications. *Renewable and Sustainable Energy Reviews*, 141: 110781.

[2] Maja, M. M., S. F. J. E. S. Ayano and Environment (2021). The impact of population growth on natural resources and farmers' capacity to adapt to climate change in low-income countries. *Earth Systems and Environment*, 5(2), pp. 271-283.

[3] Khan, I., F. Hou, M. Irfan, A. Zakari, H. P. J. R. Le and S. E. Reviews (2021). Does energy trilemma a driver of economic growth? The roles of energy use, population growth, and financial development. *Renewable and Sustainable Energy Reviews*, 146: 111157.

[4] Ali, M. U., Z. Gong, M. U. Ali, X. Wu, C. J. I. J. o. F. Yao and Economics (2021). Fossil energy consumption, economic development, inward FDI impact on CO_2 emissions in Pakistan: testing EKC hypothesis through ARDL model. *International Journal of Finance & Economics*, 26(3), pp. 3210-3221.

[5] Bae, C. and J. J. P. o. t. C. I. Kim (2017). Alternative fuels for internal combustion engines. *Proceedings of the Combustion Institute*, 36(3): pp. 3389-3413.

[6] Das, A., N. Das and M. D. Ghatak (2022). Experimental Investigation of Feasibility of Using Biodiesel Produced from Nahar, Castor, and Rice Bran Seeds in CI Engine. *Advances in Thermofluids and Renewable Energy, Springer*, pp. 339-349.

[7] Fraterrigo Garofalo, S., T. Tommasi and D. Fino (2021). A short review of green extraction technologies for rice bran oil. *Biomass Conversion and Biorefinery*, 11(2), pp. 569-587.

[8] Ohen, S.B, and Ajah E.A. (2015). Cost and return analysis in small scale rice production in Cross River State, Nigeria. *International Research Journal of Agricultural Science and soil Science*, 5(1): pp. 22-27.

[9] Monasterolo, I. and M. J. E. P. Raberto (2019). The impact of phasing out fossil fuel subsidies on the low-carbon transition. *Energy Policy*, 124: pp. 355-370.

[10] Bala, E. J., 2012. Incentives in Nigeria under Review; Director, Renewable Energy, *Energy Commission of Nigeria*.

[11] Sadeghinezhad, E., Kazi, N., Badarudin, A., Oon, C.S., Zubira, M.N.M., Mehrali, M. A (2013). A comprehensive review of bio-diesel as alternative fuel for compression ignition engines. *Renewable and Sustainable Energy Reviews*, 28, pp. 410–424.

[12] Gui, M.M., Lee, K.T., Bhatia, S. (2008). Feasibility of edible oil vs. non-edible oil vs. Waste edible oil as biodiesel feedstock. *Energy*; 33(11), pp. 1646–53.
[13] Ben-iwo, J., Manovic, V. and Longhurst, P. (2016). Biomass resources and biofuels potential for the production of transportation fuels in Nigeria. *Renewable and Sustainable Energy Reviews*, 63, pp. 172–192.
[14] Malode S.J., Prabhu K. K., Mascarenhas R.J., Shetti N.P., Aminabhavi T.M., (2021). Recent advances and viability in biofuel production. *Energy Conversion and Management: X*, 10, ISSN 2590-1745.
[15] Tan, K.T., Lee, K.T., Mohamed, A.R., Bhatia, S. (2009). Palm oil: addressing issues and towards sustainable development. *Renewable & Sustainable Energy Reviews*; 13(2): pp. 420-7.
[16] Garofalo S.F., Tommasi T. and Fino, D., (2021). A short review of green extraction technologies for rice bran oil. *Biomass Conversion Biorefinery* 11, pp. 569–587. https://doi.org/10.1007/s13399-020-00846-3
[17] Bodie A.R., Micciche A.C., Atungulu G.G., Rothrock M.J., Ricke S.C. (2019). Current Trends of Rice Milling Byproducts for Agricultural Applications and Alternative Food Production Systems. Frontiers in Sustainable Food Systems, *Frontiers*, 3, pp. 2571-581
[18] Spaggiari, M.; Dall'Asta, C.; Galaverna, G.; del Castillo Bilbao, M.D. (2021). Rice Bran By-Product: From Valorization Strategies to Nutritional Perspectives. *Foods*, 10, 85. https://doi.org/10.3390/foods10010085
[19] PWC, (2018). Boosting rice production through increased mechanisation. *Price Waterhouse Coopers*, https://www.pwc.com/ng/en/assets/pdf/boosting-rice-production.pdf
[20] Goffman, F. D., S. Pinson and C. J. J. o. t. A. O. C. S. Bergman (2003). Genetic diversity for lipid content and fatty acid profile in rice bran. *Journal of the American Oil Chemists' Society*, 80(5), pp. 485-490.
[21] Ju, Y.-H. and Vali S. R., (2005). Rice bran oil as a potential resource for biodiesel: a review. *Journal of Scientific & Industrial Research, 64*, pp. 866 – 882.
[22] Bhattacharyya, A.C., Majumdar, S. and Bhattacharyya, D.K. (1986) Edible quality rice bran oil from high FFA rice bran oil by miscella refining. *Journal American Oil Chemist Society*, 63, pp. 1189–1191.
[23] Dharmaraja, J., D. D. Nguyen, S. Shobana, G. D. Saratale, S. Arvindnarayan, A. Atabani, S. W. Chang and G. J. F. Kumar (2019). Engine performance, emission and bio characteristics of rice bran oil derived biodiesel blends. *Fuel*, 239: pp. 153-161.
[24] Hoang, A. T., M. Tabatabaei, M. Aghbashlo, A. P. Carlucci, A. I. Ölçer, A. T. Le, A. J. R. Ghassemi and S. E. Reviews (2021). Rice bran oil-based biodiesel as a promising renewable fuel alternative to petrodiesel: A review. *Renewable and Sustainable Energy Reviews*, 135: 110204.
[25] Chen X-T., Wang J-X, Dai Y-M., Wang P-H, Liou C-Y, NienC-W, Wu J-S, Chen C-C. (2013). Rice husk ash as a catalyst precursor for biodiesel production. *Journal of the Taiwan Institute of Chemical Engineers*, 44, 4, pp. 622-629.
[26] Mba C., (2021). Nigeria Milled Rice Production Over 20 years. *Chart of the Day*, https://www.dataphyte.com/latest-reports/agriculture/chartoftheday-nigeria-milled-rice-production-over-20-years/
[26] Terwase, I.T and Madu, A.Y, (2014). The Impact of Rice Production, Consumption and Importation in Nigeria: The Political Economy Perspectives. International Journal of Sustainable Development & World Policy, 3(4): pp. 90-99
[28] NNPC (2020). *Nigeria National Petroleum Corporation Annual Statistical Bulletin*, 2nd Edition. https://nnpcgroup.com/Public-Relations/Oil-and-Gas-Statistics/Pages/Annual-Statistics-Bulletin.aspx
[29] World Data Atlas, (2019). Nigeria - Biodiesel production https://knoema.com/atlas/Nigeria/topics/Energy/Renewables/Biodiesel production#:~:text=Between%202000%20and%202019%2C%20Nigeria,0%20thousand%20barrels%20per%20day.
[30] Adewuyi A., 2020. Challenges and prospects of renewable energy in Nigeria: A case of bioethanol and biodiesel production. *Energy reports*, 6, 77-88.
[31] Punch Nigeria, (2012). Daily petrol consumption hits 40.32 million litres – Investigation •Beats Reps' benchmark by 22.18%. *Punch newspaper.* http://www.punchng.com/business/financial-punch/daily-petrol-consumption-hits-40-32-million-litres-investigation-%E2%80%A2beats-reps-benchmark-by-22-18/