INTEGRATED SOLID WASTE MANAGEMENT OF THE PALM OIL MILL AS AN EFFORT TO REDUCE GLOBAL WARMING AND ENVIRONMENTAL POLLUTION

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A B S T R A C T

The increase in the palm oil industry in Indonesia is followed by an increase in oil palm empty fruit bunches (EFB/EFB) solid waste. Various EFB waste management efforts have been carried out by utilizing it as raw material for bioethanol production, briquette making, compost making, particleboard manufacturing, Biomass power plant, pulp and paper production, and biogas production. During this time the EFB management is carried out individually and has different environmental, economic and social impacts. For that reason, in this study the author developed an integrated system of managing EFB waste that are more environmentally friendly, economical and provides a better social impact to the community by utilizing some existing processing technology.

The purpose of this study was to determine the potential for mushroom cultivation using the EFB planting media which was carried out in an integrated and environmentally friendly manner, thus providing many benefits to the community and supporting a sustainable palm oil industry. The method used in this study is an experimental method and literature study that produces observational data in the form of tables and graphs that were analyzed descriptively.

The results obtained in integrated EFB management (mushroom production, biogas, compost and liquid organic fertilizer) have high economic feasibility with an investment of 1.334.468.908 IDR, IRR of 65%, B / C ratio of 2.07 and PBP for 1.5 years. Management of every ton of EFB with an integrated business concept can produce 90 kg of mushroom mushrooms, 11.14 m3 of biogas, 73.5 kg of dry compost, and 1.0 m3 of liquid organic fertilizer. Integrated management is also environmentally friendly because it is able to reduce green house gas (GHG) emissions by 436.02 kg CO2e with energy consumption of 120.17 MJ (economic value of energy 1 MJ / ton of EFB = 35.515 IDR) and provide an economic value of EFB of 4.267.885 IDR. Integrated EFB waste management can be used as a superior program for the corporate social responsibility (CSR) of palm oil mill companies to the surrounding environment.

Keywords: empty fruit bunches, mushroom cultivation, integrated system

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1. INTRODUCTION

Indonesia is the world's largest producer of palm oil (CPO). Along with the increasing demand for palm oil throughout the world, the palm oil industry also continues to increase. 85-90% of the world's palm oil needs are met by Indonesia and Malaysia (Choong et al. 2015). Within 5 years, the area of Indonesian oil palm plantations has grown by 28,63%, from 9.57 million hectares in 2012 and estimated to be 12,31 million hectares in 2017 (Indonesian Director General of Plantation 2016).

Along with the continuous increase in palm oil production, problems arise in the form of an increase in the amount of waste produced, especially the waste of empty oil palm bunches (EFB). The most being solid waste produced by the palm oil industry, which is 23% of the total fresh fruit bunches (FFB) processed (O-Thong et al. 2012). The CPO content of FFB reaches 24% and the percentage of EFB against FFB is 21% (Amelia JR *et al. 2017*).

The expansion of oil palm plantations is also an issue of global warming that is being reported intensively and widely by European countries, so that one day it will be accepted as the truth and will not help solve global environmental problems. The effects of global warming include causing global climate change (drought, floods, storms etc.) and the emergence of public health problems (respiratory problems, heat stroke and the spread of disease viruses through insects, mosquitoes, etc.)

Several EFB waste management efforts have been investigated by using it as raw material for bioethanol production (Sudiyani et al. 2013), raw material for making briquettes, raw material for composting (Nutongkaew et al. 2014), raw material for particle board manufacturing, Biomass power plant (Haryanti et al. 2014), pulp and paper manufacturing raw materials and raw materials for biogas production (Nieves et al. 2011; Chaikitkaew et al. 2015; Nurliyana et al. 2015; Suksong et al. 2016 ; Amelia JR et al. 2017)

Biogas is one type of energy that can be produced from the fermentation process of organic matter. Wet organic matter with a moisture content of 40-95% and low lignin content are generally suitable for fermentation's raw material. EFB is a solid waste that has an organic carbon content of 419,7 ± 14,2 kg / ton dry weight and nitrogen of 6,64 ± 0,05 kg / ton dry weight (Nurliyana et al. 2015). Moisture content of EFB is between 60-70% (Saelor et al. 2017) and lignin content is 31,68% dry weight (Sudiyani et al. 2013). Apart from the high lignin content, EFB has a high potential for raw material for biogas production. Mixed fermentation of EFB with LCPKS can produce biogas, compost and leachate which can be used as liquid organic fertilizer (Amelia JR et al. 2017). Conventionally, EFB waste is generally used as mulch and compost for oil palm plantations. Each ton of EFB contains nutrients in the form of N, P, K, and Mg, but the process of utilizing the EFB is less profitable because the degradation process runs very slowly ifits to be made into mulch.

The high lignin content in EFB causes the need for pre-treatment, both physically and chemically before it is used as raw material for biogas. Chaikitkaew et al. (2015) has examined several organic materials from the palm oil industry, including EFB which is dried at 95^{o}C for 48 hours as a raw material for biogas using a palm oil mill effluent (POME) activator. The results showed that a mixture of EFB and POME with a ratio of 1: 2 inoculum and substrate (I/S) incubated at 37^{o}C for 45 days, produces the highest methane gas with a production of 55 m^3 CH_4/ton. O-Thong et al. (2012) reported that EFB treated initially with the addition of 1% (w/w) NaOH and dried first at 230^{o}C, then mixed with POME with a ratio (I/S) 1: 6.8 can produce a maximum methane gas as much as 82,7 m^3 CH_4/ton. Sudiyani et al. (2013) reported that pretreatment of EFB with 10% NaOH can reduce lignin from 31,68% to 11,02%, hemicellulose from 14,62% to 5,69% and increases cellulose content from 37,26% to 68,86%.

Utilization of EFB by the community has been carried out as a planting medium for mushroom cultivation with one cycle of time valued as 1,5 month. After the mushroom cultivation was produced, the former EFB solid waste media from the mushroom cultivation media (EFBMM) texture become softer than the EFB texture before its used as cultivation media. During this time, the EFBMM waste is not managed and only piled up causing odors and reducing the aesthetics of the surrounding environment. A small number of EFBMM are used by farmers as mulch on agricultural crops.

Based on these references, EFB has a huge economic potential to be used as a raw material for mushroom cultivation media, biogas production (renewable energy), compost and liquid organic fertilizer.Those benefits were helpful in support of national food and energy security. The Institute for Essential Services Reform (IESR) study of community-based renewable energy management has many benefits. By opening opportunities for local participation and local capacity development so as to increase income and create jobs.

EFB waste management is carried out in an integrated manner, beginning with the use of EFB as a medium for mushroom cultivation, followed by the fermentation process of EFBMM. In the fermentation process, it is necessary to mix nitrogen-rich ingredients as nutrients, such as activated sludge, cow dung, chicken manure and food scraps. Utilization of EFBMM as raw material is expected to be more easily degraded than EFB, because some references state that the direct use of EFB as a raw material for biogas production is constrained by the high lignin content in EFB.Then so requires physical, chemical and biological pre-treatment. Utilization of EFB as a medium for mushroom cultivation at the beginning of the study is expected to change the composition of lignocellulose by reducing the lignin content in EFB. Utilization of EFB as a planting medium for mushroom cultivation is one of the preliminary techniques of natural (biological) EFB that is environmentally friendly. So, it is expected to facilitate the fermentation process and accelerate the process of methanogenesis to produce methane gas (CH_4).

2. MATERIALS AND METHOD

The design of this study was an experiment of the process of cultivating straw mushrooms and biogas production along with its by products of liquid compost and organic fertilizer using the main raw material in the form of EFB. Then doing the analysis of energy needs, greenhouse gas emissions and material flow rates from the process of cultivating straw mushrooms. To determine the economic feasibility of the process of mushroom cultivation using the EFB media, Net Present Value (NPV), Internal Rate of Return (IRR), Net B/C Ratio and Payback Period (PBP) analyzes were performed. Furthermore, to find out the advantages of integrated EFB processing technology in terms of technical, environmental, economic, and social aspects compared to other methods, various references related to EFB processing were collected.

3. RESULTS AND DISCUSSION

The concept of integrated EFB waste management is the utilization of EFB originating from oil palm mills (which do not have plantation) for the media for cultivating straw mushrooms, followed by biogas production (energy recovery) made from raw materials of EFB, followed by managing byproducts from biogas production, namely compost and liquid organic fertilizer. So that the integrated EFB waste management system can achieve the concept of zero waste. The management system will produce four products, namely 1. mushroom which can be used as a nutritious food source, 2. biogas which can be used as a source of renewable energy, 3. compost and 4. leachate (liquid organic fertilizer) that can be used for the cultivation of agricultural crops and 2d crops (palawidja). So that the system can also be offered to overcome problems in the palm oil industry (without plantations) in reducing the volume of the generated EFB waste.

Solid waste management that is only focused on technology alone will not be economically and environmentally effective, so a holistic waste management system evaluation is needed and that integrated EFB waste management systems can be implemented sustainably and provide benefits to the surrounding community In implementing this concept. It is also necessary to pay attention to social aspects in implementing this concept, as a whole there are 4 aspects discussed, namely 1.technical aspects, 2. environmental aspects, 3. economic aspects and 4. social aspects.

a. Technical aspects of EFB management

Various kinds of EFB processing technology have been carried out and developed by many researchers to produce energy sources and other products of economic value. The availability of this technology allows EFB to be used as a substitute for raw materials that have been used. EFB is a renewable raw material so that its availability can be produced throughout the year. Of the several technologies that have been used in the production of ethanol, briquettes, thermal and electric energy generation, particle board and pulp and paper are products that require complex technologies and require greater energy. This is because in each production process there is a boiling process (steam), drying or combustion that requires special equipment, it also cannot be implemented on a small or simple scale by the general public. The Compost production process is the simplest technology followed by methane production. Both of these processes can be applied or carried out by individuals (communities) by getting short training.

The integrated EFB management system is an uncomplicated technology, because it does not use much equipment and the equipment used is also easy to operate and does not require large amounts of energy. The results of the calculation of energy consumption needed to process each ton of EFB in an integrated system begins with the process of mushroom cultivation and continued with the production of biogas that produces by-products (residues) in the form of Compost and liquid organic fertilizer. These are presented in Table 1.

Table 1. Energi consumption from each management of 1 tons of EFB

Equipment	Power	Use (hour)	Amount of energy (MJ)	Information)*
Water pump	500 watt	1	64,80	
Circulation pump	200 watt	1	25,92	1kWh = 3,6 MJ
Humidifier	250 watt	2	16,20	
Crusher Compost	20 pk	0,6	21,60	Fuel consumtion = 1 l/jam 1l Diesel Fuel = 36,0 MJ
Steam	-	4	94,25	9 kg LPG =7,25m^3 Biogas 1 m^3 Biogas = 22,1 MJ
	Total energy consumption =		222,77	

Source :)* Wibawa U (2017)

The energy consumption of integrated EFB management (Table 1) when compared to some of the existing EFB management technologies has been lower compared to methane production alone and is higher than brackets and Compost production alone (Table 2). Managing it with an integrated system produced four products, namely 1. fresh straw mushrooms, 2. biogas, 3. Compost and 4. liquid organic fertilizer, comparing it to the production of brackets and Compost that only produce a single product.

Table 2. Energi consumption per tons of EFB from various methods

Utilization Technology EFB	Pupl and Paper	Ethanol	Particle board	Metana	Heat and Electricity	Briquett	Compost	Integrated Product
Energy (MJ)	4200 [a)]	1300 [a)]	1070 [a)]	520 [a)]	360 [a)]	166 [a)]	38 [a)]	222,77[b)]

Source: [a)] Chiew dan Shimada (2013), [b)] research

The energy consumption of other EFB technology (Table 2) shows that the production of pulp and paper made from EFB is a processing technology that consumes the most energy, ie ± 4,2 GJ to process one ton of EFB compared to other technologies. Followed by the ethanol production process that requires energy ± 1,3 GJ and particle board production ± 1,07 GJ. Composting technology made from EFB is a process that consumes the lowest energy compared to others because it only uses machines and small vehicles. Technologies for methane production, heat and electricity generation and EFB briquettes are 520 MJ, 360 MJ and 166 MJ, respectively (Chiew and Shimada 2013).

The methane production technology carried out in this research is dry fermentation technology using raw materials used in the former mushroom media EFB (EFBMM), so there is no need for a pre-treatment process for raw materials thus have a direct impact on reducing energy use. As stated by Chiew and Shimada (2013), to produce 1m^3 of methane made from EFB requires 520 MJ/kg EFB of energy. The energy is needed for the pretreatment of EFB raw material through a hydrothermal process before being soaked in NaOH solution (O-Thong. 2012). If the fermentation process uses EFBMM raw materials, then no pre-treatment process is needed so thus the methane production process in the study can save energy by 520 MJ/kg EFB.

b. Environmental aspects of EF B Management

Seen from the environmental aspect, without regard to the unwanted products (avoided) of each EFB processing technology, Composting technology is the most environmentally friendly EFB processing technology, because it has the lowest value for almost all impact categories, except for freshwater ecotoxicity and mainland ecotoxicity (Chiew and ShImada 2013). Ecotoxicity of Compost is the nature of toxic substances from substances contained in Compost and can disrupt the ecology of freshwater and land (ecotoxicity). theecotoxicity of Compost production is higher than that of methane and briquette production processes, due to the presence of substances that are not expected to be present in the Compost content. In addition to the beneficial elements (C, N, P, K, Ca, S, Mg), Compost products also contain heavy metals (Mn, Zn, Cu, Cr, Pb and Cd) in small amounts (trace elements), so if the processing and use are not according to the rules it can pollute the freshwater and soil environment (Baharudin et al. 2009).

Methane production and briquette production are the best performing technologies. Methane production from EFB has a very high impact on eutrophication compared to other recycling technologies. Eutrophication is a process in which a plant grows very fast compared to normal growth (blooming). This is due to the production of methane produced by-products in the form of Compost and effluent which is rich in C, N, P and K. However, if the liquid waste is treated and managed properly, it can be used as liquid organic fertilizer.

Composting has the least impact on the environment, followed by briquette production, board production particles, thermal and electricity energy generation, methane production, ethanol production and pulp and paper production. For the category of green house gas (GHG) impacts, pulp and paper production has the highest impact value with emissions of 361,8 $kgCO_2e$, and followed by ethanol production 159,6 $kgCO_2e$, methane production 108,6 $kgCO_2e$, heat and electricity generation 100,0 $kgCO_2e$, particle board production 61,2 $kgCO_2e$, briquette production 43,7 $kgCO_2e$ and Composting 22,2 kg CO_2e.

Table 3. The impact of 1 tons EFB production on GHG Effect ($kgCO_2e$)

Utilization Technology EFB	Ehanol	Metana	Brikket	Heat and Electricity	Compost	Particle board	Pupl and Paper	Integrated Product
GHG Effect	159,6 [a)]	180,6 [a)]	43,7 [a)]	100,0 [a)]	22,2 [a)]	61,2 [a)]	361,8[a)]	22,2

Source: Chiew dan Shimada (2013) and research

Each management of one ton of EFB conducted in an integrated manner contributes to reducing global warming as a result of GHG emissions by 436,02 $kgCO_2e$. This contribution is significant and the highest compared to other EFB processing technologies (Table 4).

Table 4. The impact of 1 tons EFB production on reducing GHG Effect ($kgCO_2e$)

Utilization Technology EFB	Ehanol	Metana	Brikket	Heat and Electricity	Compost	Particle board	Pupl and Paper	Integrated Product
Reduction GHG	39,9 [a)]	154,6 [a)]	19,2 [a)]	218,6 [a)]	176,5 [a)]	0,5 [a)]	2,9 [a)]	436,02

Source: [a)]Chiew dan Shimada (2013) and research

According to Chiew and Shimada (2013) thermal and electricity generation technology can reduce GHG emissions by 218,6 $kgCO_2e$, Composting and methane production by 176,5 $kgCO_2e$ and 154,6 $kgCO_2e$ respectively. In this study the semi-dry fermentation process can reduce GHG emissions of 436,02 $kgCO_2e$ for each ton of EFB. By considering unwanted products, GHG emissions in briquette and ethanol production can be reduced by 44% and 25%, respectively. However particle board production and pulp and paper production did not gave significant reduction (<1%).

From the description above, it can be stated that the integrated management of EFB produce mushrooms, biogas, Compost and liquid organic fertilizer is a business that is very profitable economically. Environment wise also great because integrated management of EFB will actually reduce the impact on global warming, based on other references this technology eventually could also reduce the impact of acid rain, abiotic reduction, freshwater ecotoxicity, human toxicity, seawater ecotoxicity, ozone depletion, photochemical oxidation and terrestrial ecotoxicity (Chiew and Shimada 2013).

The content of N, P, K and C of Compost produced from each dry weight in this study were 2,09%, 1,38%, 0,77%, and 28,81% and the C / N ratio 13, respectively. 79 The fertilizer fulfills the requirements of SNI No. 19-7030-2004, namely 9,8 - 32% Carbon content, minimum Nitrogen content of 0,10%, C/N Ratio 10-20, minimum Phosphorus (P_2O_5) content of 0,10% and minimum Potassium (K_2O) content of 0,2%. The content of liquid organic fertilizer elements from the methane production process are respectively N = 1,88%; P = 0,08%; K = 3,58% and C = 31,58.

c. Economic aspects of EFB Management

The results of the feasibility analysis with an economic age of 10 years and a deposit interest rate of 6,10% show the integrated efforts of managing EFB provide the greatest benefit with an NPV value of 1.334.468.908 IDR. The business are also feasible and profitable to be implemented with an IRR value (65%) higher than the discount rate (6,10%) and a Net B/C value of more than one (2,07) with the time required to return varying capital One and a half (1,5) years.

d. Social Aspects of EFB Management

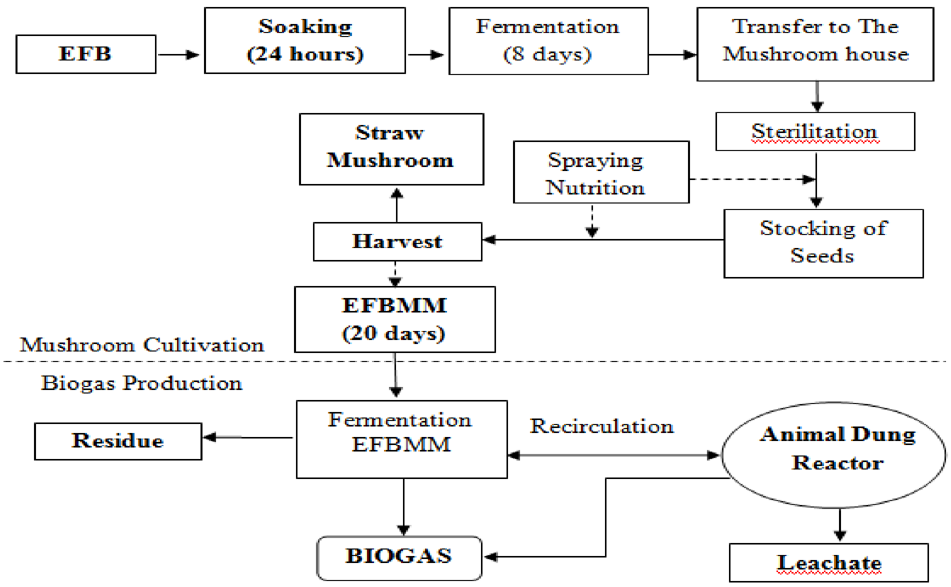
From a social standpoint, an integrated system of managing EFB in an integrated manner in the form of utilization of EFB for the cultivation of straw mushroom and biogas production is expected to be specifically able to **provide social benefits to the surrounding community** and in general can also provide benefits for other activities in the form of:

1. Opening employment opportunities, integrated efforts to manage EFB can absorb a minimum of 10 workers
2. Improving the welfare of the surrounding community in the form of an increase in average income ranging from 1.000.000 IDR up to 3.000.000 IDR per month (survey results).
3. Assist the availability of organic fertilizer for farmers
4. As a place for the development of science.
5. The socially integrated EFB management effort has also helped solve the problem of the Palm Oil Mill company, especially those who do not have oil palm plantations in managing the EFB solid waste.

Based on the social aspects that have been outlined, the integrated system of integrated EFB management in the form of a business of cultivating straw mushrooms, biogas production, Compost and liquid organic fertilizer can provide enormous social benefits because it helps the community in improving welfare and helps palm oil mill companies in solving solid waste management problems.

e. Implementation of integrated EFB management

The integrated implementation of EFB management in this study is illustrated by the flow chart of Figure 1. and Table 6. which began with the cultivation of 10 mushroom house. Each mushroom house requires 1,7 tons of EFB raw material to be used as planting media, so that the total requirement for EFB raw material for 10 mushroom house is 17 tons/cycle or 120 tons/year. After the mushroom cultivation, former EFBMM mushrooms experienced a shrinkage of up to 40% to 10 tons. After the cultivation of the mushroom EFBMM was immediately utilized for biogas production using a 10x1 ton EFBMM fermentation reactor made in parallel configuration. EFBMM fermentation is done by dry fermentation, which is fermentation done by adding an inoculum (cow dung solution) with a recirculation system into the EFBMM reactor. In this system the inoculum is prepared in an animal dung reactor with a capacity of 12 m^3.



Picture 1. Flow Chart Integrated process EFB Management

The type and amount of material used and the products produced in each process (Table 6) in the integrated EFB management of biogas production in addition to being produced from the EFB fermentation process (3,10 m^3/day), also produced from animal dung reactors (2,50 m^3/day), so the biogas production produced is 5,6 m^3/day or 168 m^3/month. Every day the animal dung reactor is added with fresh cow manure as much as one truck load (0,065 m^3). The biogas produced is used for the sterilization process of mushroom house, with the need for each mushroom house in one cycle is 10 m^3. If in one month the sterilization process is carried out 5 times, then there is still a surplus of biogas 118 m^3/month. The advantages of biogas can be used for cooking and lighting made from biogas and if possible help to the needs of the surrounding community by flowing it using a piping network system.

Table 6. Types and quantities of materials and products of integrated management EFB

Input/Output	Unit	Mushroom cultivation (10 house)	EFBMM Reactor (Cap.10x1 ton)	Animal Dung Reactor
INPUT (Material)				
EFB	Kg	17.000	-	-
EFBMM	Kg	-	10.000	-
EFB Submersion water	L	-	-	10.000
Solid Animal dung	kg/day	-	-	78
OUTPUT (Produk)				
Mushroom	Kg	1.500	-	-
EFBMM	Kg	10.000)[a]	-	-
Wet Residue	kg/month	-	5.000)[b]	-
Biogas	m^3/day	-	3,10	2,50
Leachate	L/month	-	-	5.000

Information: EFB content capacity of each mushroom house = 1.700 kg
1 kg cow dung = 0,0320 m^3 biogas; 1 kg EFBMM = 0,0186 m^3 biogas
Density of cow dung = 1.200 kg/m^3 (Wardhani and Warsono 2013)
)[a] EFB depreciation ± 40%
)[b] Dismantling of wet compost/month 5 reactors carried out alternately.

The development of an integrated system of managing EFB waste in the form of mushroom cultivation and integrated biogas production is highly recommended, because it can help overcome the problems of handling the generation of EFB waste, especially in palm oil mill companies that do not have oil palm plantations.

The results of an integrated management calculation per ton of EFB (Table 7) can increase the economic value of EFB by 4.267.885 IDR. With the energy consumption needed to manage 1 ton of EFB of 222,77 MJ, the energy per 1 MJ used is of economic value of 19.158 IDR. The value is much higher than the use of 1 MJ of energy in Compost production (energy = 38 MJ), with an economic value of energy per 1 MJ of 6.769 IDR and if only for biogas production (energy = 520 MJ) the economic value of energy per 1 MJ used is 4.400 IDR.

Table 7. Economic value resulting from processing 1 ton of EFB

Technology	Potential and assumption	Unit	Economic value
Mushroom Cultivation	Mushroom = 90 22.000 IDR/kg	kg	1.980.000 IDR
Fermentation EFB post Mushroom cultivation Media (EFBMM)	Biogas Production = 11,14 1m^3 biogas ~ 0,5 liter Diesel Fuel [a)] 1 liter solar = 5.500 IDR	m^3	30.635 IDR
	Compost = 73,5 Water content = 20 3.500 IDR/kg N = 2,09 (chemical fertilizer 46%) P = 1,38 (chemical fertilizer 50%) K = 0,77 (chemical fertilizer 60%)	kg % % % %	257.250 IDR Each 1 ton of Compost is equivalen: 45,43 kg fertilizer N 27,60 kg fertilizer P 12,83 kg fertilizer K
	Liquid fertilizer prodcut = 1,0 2.000 IDR/L N = 1,88 P = 0,08 K = 3,58	m^3 % % %	2.000.000 IDR
		Total economic value	**4.267.885 IDR**

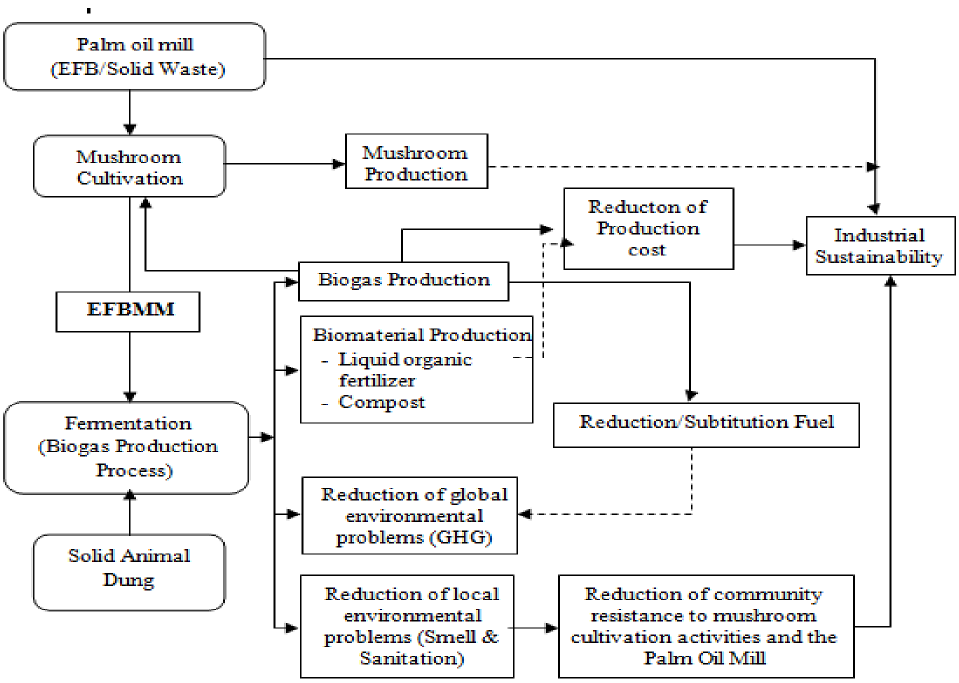
The availability of raw materials comes from palm oil mills which have a minimum capacity of 30 tons of FFB/hour with an operating time of 20 hours/day and 6 days/week. If EFB produced from palm oil mill is 23% of FFB. The number of EFB produced

= 30 tons/hour x 20 hours/day x 6 days/week x 23%
= 828 tons/week Or
= 3.312 tons/month

So that if the management of EFB is done optimumly using an integrated system, then from 3.312 tons/month the EFB waste, it has the potential to produce straw mushrooms of 298,08 tons, biogas 36.896 m^3, Compost fertilizer 243,43 tons and 3.312 m^3 of liquid organic fertilizer with an economic value as much as of 14.135.235.120 IDR.

Integrated EFB management greatly contributes to the environment and social because it can reduce:

1. The use of chemical fertilizers, EFB waste management in an integrated manner produces organic fertilizers that are more environmentally friendly as an integrated system replacing chemical fertilizers.
2. The use of fossil fuels and wood fuels because they can be substituted by the biogas produced, so they can also reduce the production costs of the business.
3. GHG emissions of 436,02 kgCO_2e for each management of one ton of EFB.
4. Local environmental problems, especially the problem of odor and environmental sanitation that directly intersect with the community,.
5. Community resistance, especially to mushroom cultivation business, because the social and economic benefits are directly felt and generally for palm oil mill industres activities as producers of EFB waste which can be managed for productive businesses.



Picture 2. Integrated EFB management greatly contribution

With so many social and economic benefits that are directly felt by the community, it is hoped that integrated EFB management efforts and palm oil mill factory activities can be received with a good response by the community, so that the sustainability of each of these businesses can be maintained. To maintain this sustainability commitments are required and cooperation between the integrated EFB management and palm oil mill companies, especially in maintaining the availability of EFB raw materials.

With the many benefits of an integrated EFB management system, it is hoped that there will be attention from companies and the local government to encourage these activities. Companies can help the community in the form of CSR activities. The amount of EFB waste that reaches 138 tons/day (828 tons/week) or 3.312 tons/month (palm oil mill with a production capacity of 30 FFB/day), will not be finished managed by one integrated EFB processing unit (10 mushroom house capacity) that only consumes 17 tons of EFB per cycle (1 cycle = 1,5 months), so we need other integrated EFB processing units in order to reduce the generation of EFB in the factory.

6. CONCLUSION

The application of integrated EFB Management capacity of 120 tons/year (mushroom production, biogas, compost and liquid organic fertilizer) has the highest feasibility with an investment worth of 1.334.468.908 IDR, IRR of 65%, B/C ratio of 2,07 and PBP for 1,5 years.

Each management of one ton of EFB with an integrated business concept can produce 90 kg of straw mushrooms, 11,14 m^3 of biogas, 73,5 kg of dry Compost fertilizer, and 1,0 m^3 of liquid organic fertilizer. The integrated business is also environmentally friendly because it is able to reduce greenhouse gas emissions by 436,02 kg CO_2e with energy consumption of 120,17 MJ (economic value of energy 1 MJ/ton of EFB = 19.158 IDR) and provide an economic value of EFB of 4.267.885 IDR. Thus the concept of integrated EFB waste management can be used as a superior program for the corporate social responsibility (CSR) of companies to the surrounding environment.

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