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Waste Utilization Potential of Oil Palm Industry in North Kalimantan Province, Indonesia

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Abstract: This research is aimed to identify the potential economic value of oil palm waste utilization and to construct an environmentally friendly business model based on oil palm waste utilization for the context of North Kalimantan Province. Method of research is descriptive using both quantitative and qualitative specifications. The results of research showed that plantation enterprises and farmers do not yet optimally utilize and manage oil palm waste into economically valuable products. The population around oil palm plantation perceive that oil palm waste from oil palm enterprises is safe and never bringing negative impact on environment. Economical value potential from oil palm waste utilization has been calculated and the number is positive and profitable. Other result indicated that the construction of a business model regarding oil palm waste management involves a collaboration between plantation enterprises, farmers and Village Enterprise (Bumdes-Badan Usaha Milik Desa) as the representative of community around the plantation. The expectation is that the utilization of oil palm waste will improve the welfare of farmers and community members, protect the environment and prevent social conflict concerning waste from happening.

Keywords: waste; environmentally friendly business; economic value; social conflict; waste negative impact.

JEL Classification: Q20; Q53; O30; R11.

Introduction

Oil palm plantation industry is one of strategic sectors in Indonesia. Total width of oil palm plantation area, comprising of state plantation, private plantation and people plantation (PIR – *perkebunan inti rakyat*), has been significantly increasing every year. In 2010, the area of oil palm plantation was totally 8,548,828 Ha and until 2017 (seven years), the number was increasing by almost 44% or becoming 12,298,450 Ha (BPS-Indonesia, 2017). Production and volume capacities for the exported crude palm oil (CPO) and the derivatives were increasing with the expansion of total plantation area. According to the report from the Association of Indonesian Oil Palm Industrialists (GAPKI-*Gabungan Pengusaha Kelapa Sawit Indonesia*), production capacity of palm oil was 41.98 millions tons in 2017, which is an increase by 18% compared to the 2016 production (35.57 millions tons). The

value of the exported palm oil in 2017 was quite promising, which is an increase by 23% or from 25.11 millions tons in 2016 to 31.05 millions tons in 2017.

The growth in total area width of oil palm plantation and also in production capacity of palm oil was relatively high which then surely gives positive impact on economic in the form of absorbing workforces and contributing foreign exchange. However, oil palm agroindustry affects the environment negatively. Pursuant to the opinion given by Syahza (2019), the expansion of oil palm plantation in Indonesia was not entirely followed by the proper environmental management system. Instead, the production from oil palm industry is potentially destructive to the surrounding environment. Converting forests into oil palm plantation has brought negative consequences such as changing ecosystem dramatically that may eliminate ecological function of soil; triggering greenhouse gas emission, deforestation, and forest fire; and potentially causing social conflict between plantation enterprises and community around the plantation.

Oil palm plantation enterprises, including those with and without palm oil processing mills, are indeed potentially causing environmental pollution through their production waste. The production of both palm oil and oil palm core only needs 25% of total weight of oil palm fresh bunch whereas the remaining of 75% weight becomes waste. Oil palm waste is differentiated into three forms, respectively solid, liquid and gas. Solid waste includes empty bunch, shell, and fiber. More specifically, one ton of oil palm can yield 230 kg empty bunch (23%), 65 kg shell waste (6.5%), and 130 kg fiber waste (13%) (Dirgantoro and Adawiya 2018). Palm oil processing leads to liquid waste which is commonly known as POME (*Palm Oil Mill Effluent*). In calculation, one ton of palm oil production can leave total waste for 550kg – 675kg, precisely 55%-67% of total production capacity (Maryadi 2006). Meanwhile, gas waste from oil palm industry usually takes two forms. First gas form is combustion gas from the burned shell and fiber, although the emission of this burning is used for electric generation system. Second gas form is methane and carbondioxide which go up in the air from liquid waste treatment ponds.

If these byproducts (waste) are not properly treated, this waste will be potentially pollutive to the environment. Solid waste from oil palm fiber contains nutrients, phosphor (P), calcium (Ca), magnesium (Mg), and carbon (C) that provides fertile ground for bacterial growth (Hariyanti *et al.* 2014, Pratiwi and Usman 2016). Moreover, the smell of this solid waste is quite unpleasant. Liquid waste from palm oil contains *Biochemical Oxygen Demand* (BOD), *Chemical Oxygen Demand* (COD), and highly suspended solids that can diminish water fertility (Chan *et al.* 2013). In addition, liquid waste of oil palm is extremely dangerous to the environment because the waste is toxic and initiating methane (CH_4) and carbondioxide (CO_2) that later cause greenhouse effect emission (Maryadi 2006, Silalahi and Supijatno2017, Loekito 2002). Gas waste from oil palm production can increase CO_2 level that may trigger air pollution.

Referring to the explanations above, the establishment of oil palm plantation helps increasing foreign exchange income and improving the welfare of oil palm farmers. Unfortunately, the management of oil palm industry does not follow environmental management system and sustainable agriculture system, which later engender a huge negative impact on environment and community. The expectation is that the establishment of oil palm plantation shall be integrated with environmental, economical and social aspects, or at least be complying with sustainable development concept that requires a harmony across environmental, economical and social dimensions (Syahza 2019).

Managing oil palm waste into useful products is an effort with positive impact, at least for the goal of creating harmony across environmental, economical and social dimensions. Oil palm waste can be utilized economically to create several related businesses that conform to the effort of reducing environmental pollution. The findings of previous studies showed that oil palm waste, especially solid waste and liquid waste, can be utilized and processed into new products with economic value. Solid waste can be processed into fertilizer, fuel, pulp, vapor for electric generator, charcoal, compost and livestock feed (Afifah *et al.* 2016b, Haryanti *et al.* 2014, Silalahi and Supijatno 2017, Dirgantoro and Adawiya 2018). Interestingly, liquid waste has been successfully utilized as raw material in the production of soap, cosmetics and organic fertilizer (Afifah *et al.* 2016b, Silalahi and Supijatno 2017, Maryadi 2006).

The current research sees a potential behind the utilization of oil palm waste and this potential provides business opportunity to the community around the industrial area of oil palm plantation in North Kalimantan Province. The 2016 data from BPS showed that the oil palm plantation (including state plantation, private plantation, and people plantation) in North Kalimantan Province has total area of 50,347 ha with CPO production reaching 167,668 tons. In 2017, total area of oil palm plantation has extended by 37% to 69,196 ha with CPO production increasing by 8% to 181,737 tons (BPS-Indonesia, 2017). Based on the 2017 data, CPO production in North Kalimantan Province has delivered solid waste for approximately 38,563 tons (23% of 181,737 tons). This

waste level is quite serious and surely requiring immediate treatment that corresponds to sustainable environmental and agricultural management system.

Concerning with matters above, the current research becomes an important early step for giving benefit to local, regional and national levels. Taking into consideration of those matters, this research sets several goals, respectively: (1) to find out the negative impact perceived by the community from oil palm waste, (2) to inquire the utilization of oil palm waste that has been conducted, (3) to estimate the potential economic value of the utilization of oil palm waste as business alternative, and (4) to construct the model of oil palm waste utilization that involves community and oil palm enterprises. The suggested business model is the activity of oil palm waste utilization that is directly managed by community and farmers with a collaborative relationship with oil palm industry (oil palm enterprises). Previously, the utilization of oil palm waste is only managed by the enterprises or industry and without involving the surrounding community. This business model is expected to be able to create mutual partnership between oil palm industry (enterprises), farmers and surrounding community in North Kalimantan Province. By applying this model, the expectation is that the environment can be kept away from the pollution of oil palm waste and also that the surrounding community can improve their income by utilizing oil palm waste in economic way. Else, oil palm enterprises can be enforced to ensure that their production activity is already environmentally friendly. Production viability is needed to ascertain that the products are good and in compliance with environmental management standard which make the products eligible for export and to be helpful for increasing national foreign exchange.

1. Literature Review

1.1. Oil Palm Waste

There are two products delivered by oil palm mills, respectively crude palm oil (CPO) and palm kernel oil (PKO). Many different products can be obtained from the processing of CPO, including biodiesel and processed palm oil for frying, baking and other cooking activities (Barthel *et al.* 2018). Meanwhile, PKO is the main raw material for the production of natural fatty alcoholic substance, which later is processed into shampoo and liquid detergent (Barthel *et al.* 2018).

Palm oil products can yield a huge amount of waste or residuals in the forms of shell, empty bunch and fiber (Abdullah and Sulaiman, 2013, Promraksa and Rakmak, 2020). Besides, main byproduct of CPO production is liquid mud waste known as palm oil mill effluent (POME) (Vairappan and Yen 2007). According to Haryanti *et al.* (2014), oil palm waste is the remnants from the treatment of oil palm plants which are not included in the processing of main products. But, oil palm waste can also be found after the processing of oil palm and the waste may take form as solid, liquid and gas. Therefore, oil palm waste can be associated not only with the residues of oil palm plants harvested from the plantation but also with the inclusive materials from the processing of palm oil.

So far, oil palm waste creates a problem related with waste management. Main principle of waste management is to minimize and recycle the waste, to recover the energy from the waste, and finally, to discard the waste (Gollakota *et al.* 2020). Before understanding the best waste management system, the detail about the byproducts of palm oil production needs to be investigated.

1.2. Types of Oil Palm Waste

The type of oil palm waste is varying and increasing in numbers with the expansion of production activity. In general, oil palm waste is differentiated into three, respectively solid waste, liquid waste and gas (pollutant) waste. All these waste can represent either the residues of harvested oil palm plants from the plantation or the inclusive materials from palm oil processing.

1.Solid Waste

Solid waste of oil palm consists of empty bunch, fiber, shell and wet solids. In average, one ton of oil palm fresh bunch can yield empty bunch waste for 220 kg (22%), fiber waste for 130 kg (13%), wet decanter solids [*lumpur sawit*] for 40 kg (4%), and shell waste for 60 kg (6%) (Afifah *et al.* 2016b, Haryanti *et al.* 2014).

2.Liquid Waste

Liquid waste is often associated with the residue of palm oil production. The appearance of this waste is like gelatins with blackish color. This waste is often known through a term of POME (*Palm Oil Mill Effluent*) (Dirgantoro and Adawiya 2018).

3.Gas (Pollutant) Waste

Gas waste from oil palm industry includes combustion gas from the burned shell and fiber and methane and carbondioxide from liquid waste treatment ponds.

1.3. Impact of Oil Palm Industry and Oil Palm Waste

Oil palm plantation has successfully improved the income of rural farmers compared to other livelihoods. Therefore, in the context of this research, oil palm plantation has a great contribution to the economic development of rural area and also of oil palm producer countries through their cooperative relationship. Converting the forest into oil palm plantation and oil palm industry without compliance with sustainable agriculture principle may give bad impact on environment and society (Barthel *et al.* 2018, Utomo *et al.* 2019). Environmental impact of this unwise land conversion comprises of: deforestation; loss of biological diversity (partially due to forest degradation); greenhouse gas emission from the change of land use and from the utilization of palm oil as raw material for biodiesel; the activity at oil palm plantation and at palm oil mills; the use of fire and the consequences; air pollution (including vapor fog); and water polution. Social impact of such ignorant land conversion consists of: forced use of land right; the emergence of smallholding farmers (with small livelihood, low income and improper welfare); forced laborer and child workers; and inhuman work conditions and requirements (regarding wage, health and safety).

Furthermore, the production of palm oil can release waste that is dangerous for the environment. As previously stated, fiber waste can have unpleasant smell and also be the source of bacterial growth (Haryanti *et al.* 2014). Liquid waste from palm oil production may contain *Biochemical Oxygen Demand* (BOD), *Chemical Oxygen Demand* (COD), and wet decanter solids that can reduce water fertility (Chan *et al.* 2013). Moreover, this liquid waste also initiates the emergence of methane (CH_4) and carbondioxide (CO_2) that cause greenhouse effect emission and endanger the environment (Maryadi 2006, Silalahi and Supijatno 2017, Loekito 2002). Else, oil palm waste contains a great sum of inorganic compounds, including heavy metals (copper, lead, silver, zinc, iron, nickel, etc), which have harmful effect on microorganism (Sugiharto 1987, Tsouko *et al.* 2019).

1.4. Utilization of Oil Palm Waste

Oil palm waste can be handled economically by utilizing this waste to be reprocessed into the useful product with economic value. Previous studies have examined the utilization of waste from palm oil production. The following table presents waste type, utilization of oil palm waste and the studies that examine these items.

Table 1. Various Utilization Types of Oil Palm Waste

Waste	Utilization	Reference
Solid waste; empty bunch	Empty bunch is used as raw material in the making of compost and charcoal. At final form, empty bunch is used as fertilizer.	(Afifah *et al.* 2016b, Haryanti *et al.* 2014)
Solid waste; oil palm leaf	Oil palm leaf is used as support material in the making of coffin, furniture, house roof, and souvenir products.	(Singh *et al.* 2010)
Solid waste; oil palm fiber	Oil palm fiber is used as the fuel material for boiler. The burning in the boiler produces vapor that will be used in electric generator.	(Afifah *et al.* 2016b, Haryanti *et al.* 2014, Silalahi and Supijatno 2017)
Solid waste; oil palm stem	Oil palm stem is used in the production of laminated veneer lumber (LVL). The stem of Indonesian oil palm has been recognized for flexibility and compressive strength, which make Indonesian-made LVL compatible to Malaysian LVL, which is usually made from Malaysian oak wood (or rubber wood), a wood species often used in the manufacturing of furniture in Malaysia. The Indonesian oil palm stem-based products are almost comparable to the Malaysian oak stem-based products in relation to solidity, flexibility and compressive strength.	(Nordin *et al.* 2004, Ghani *et al.* 2022)
Solid waste; shell	Shell waste is used as raw material in the making of active charcoal. Chemical contents in active charcoal (carbon compounds) can be used in water purification process.	(Afifah *et al.* 2016b, Haryanti *et al.* 2014)
Solid waste: fiber	Fiber waste is utilized as the material in the making of pulp (paper porridge)	(Haryanti *et al.* 2014)
Solid waste; wet decanter solids	Wet decanter solids are used as raw material in the making of compost.	(Afifah *et al.* 2016b)
Solid waste; empty fruit bunch	Empty fruit bunch of oil palm (TKKS- *tandan buah kosong kelapa sawit*) can be converted into pulp. This potential	(Abdullah and Sulaiman 2013)

Waste	Utilization	Reference
	has been confirmed by MPOB because TKKS is categorized as plant residue with high fiber constituents. Paper material from TKKS can be casted and formed easily.	
Solid waste; empty fruit bunch	Other utilization of TKKS includes fuel for electric generator, biomass, fertilizer and bioethanol.	(Haryanti *et al.* 2014)
Liquid waste; sludge oil	Sludge oil is liquid waste that resembles gelatin with blackish color. This waste is used as raw material of soap, cosmetics and others. Liquid waste from palm oil mills has a good nutrient level which is potential to be used as liquid organic fertilizer.	(Afifah *et al.* 2016b, Maryadi 2006)
Solid waste	Solid waste of oil palm has energy potential which can be utilized as fuel for electric generator, charcoal briquet, pulp material, livestock feed, and fertilizer.	(Dirgantoro and Adawiya 2018)
Solid waste; fiber	Fiber contents in empty bunch and empty shell can be utilized as material in the admixture used for the production of lightweight concrete brick that needs to be environmentally friendly.	(Fitriadi and Fatahillah 2017, Abrar and Abdillah 2019)
Solid waste; empty shell	Empty shell is a material in the admixture used for the production of lightweight concrete brick that needs to be more economic and environmentally friendly.	(Oktarina and Natalina 2013, Oktarina and Natalina 2018)

Source: Data collected in this research

Based on the contents in Table 1, solid waste and liquid waste of oil palm can be utilized to be processed as products with economic value that gives alternative income to the community. The utilization of these waste provides a new way toward entrepreneurship that involves farmers, community and oil palm enterprises (palm oil mills) in a collaborative relationship.

2. Methodology

Data type of this research is primary and secondary. Primary data were collected through survey, interview and questionnaire. Respondents include community members, farmers groups and Village Enterprise (Bumdes). The respondents must live in the vicinity of oil palm plantation in North Kalimantan Province. Secondary data were obtained from the institutions that release data concerning oil palm plantation. These institutions are Central Bureau of Statistics for North Kalimantan Province and government offices in North Kalimantan Province that handle oil palm-related activity.

Research type is descriptive with both quantitative and qualitative specifications. Descriptive research is usually aimed to produce description, illustration, or drawing in systemic, factual and accurate manners about events, characteristics and relationships across the targeted phenomena (Sugiyono 2012). Analytical instrument for quantitative specification is used to analyze the economic value of oil palm waste utilization. This economic value is associated with the income realized from selling the waste to free market or from utilizing waste into profitable products. Mathematic formula of this economic value is written as follows (Sunyoto 2013):

$$I = TR - TC \quad 2.1$$

Where, I = Income (IDR/month), TR = Total Revenue (IDR/month), and TC = Total Cost (IDR/month). Total economic value comprises of what so called direct use value and indirect use value.

Direct use value (N1). Direct use value is economic value of the waste that is directly sold. Such waste usually takes forms as liquid waste and solid waste. The formula for direct use value is written as follows:

$$N = (P\ x\ Q\ ) - TC \quad 2.2$$

Where, N = Value of liquid/solid waste (IDR/month). P = Price of liquid/solid waste (IDR/kg), Q = Production of waste (IDR/month), and TC = Total Cost (IDR/month)

Indirect use value (N2). Indirect use value is economic value of the waste that is utilized into another product (not for sale). The usual form of this utilized waste is liquid waste and solid waste. The formula for indirect use value is written as follows:

$$N = (\ Q\ x\ P) - TC \quad 2.3$$

Where, Q = Waste level (kg/month), P = Sale price (IDR/kg), TC = Total Cost (IDR/month). Taking into consideration of all equations above, total economic value can be calculated by the following formula:

$$NET = \sum Direct\ Use\ Value + \sum Indirect\ Use\ Value \quad (2.4)$$

3. Case Study: Oil Palm Industry in North Kalimantan Province

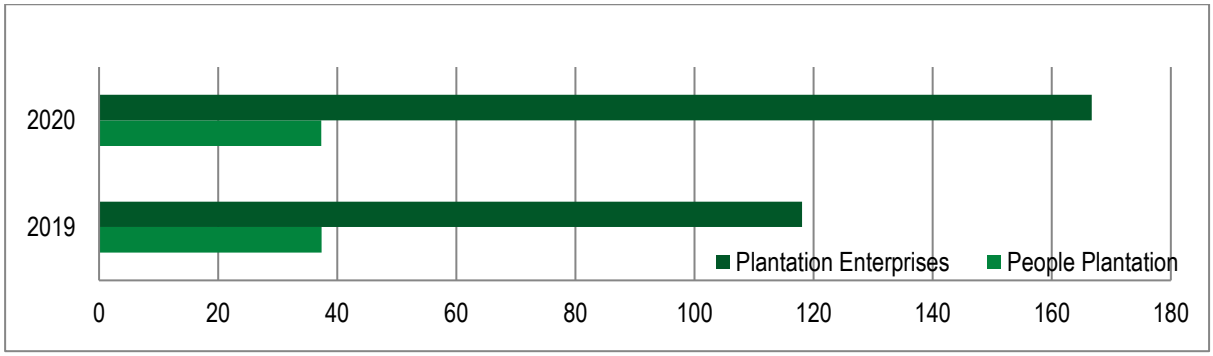
3.1 General Description of Oil Palm Industry in North Kalimantan Province

Oil palm commodity is one of leading sectors that support the economic of North Kalimantan Province. Oil palm is a plantation commodity that is available abundantly in this Province. In 2020, Plantation alone contributed by 3.26% to Gross Regional Domestic Product of North Kalimantan Province. In addition, plantation also contributed by 19.78% to the Sector of Agriculture, Forestry and Fishery of North Kalimantan Province (BPS-Kaltara 2020). Oil palm plays quite important role in economic activity of North Kalimantan Province and also Indonesia. The processing of oil palm can deliver vegetable oil and various processed products needed by industries. Having a wide area of oil palm plantation, North Kalimantan Province has a great potential to trade oil palm and oil palm core in the domestic and foreign markets.

The BPS data in 2017 indicated that the area width of oil palm plantation in Indonesia has reached 12.38 millions hectares. The width had expanded annually and became 14.59 millions hectares in 2020. One reason of this expansion is the increase of administrative area of oil palm plantation managed by oil palm enterprises. In North Kalimantan Province alone, total area width of oil palm plantation is around 204 thousands hectares dominated by plantation enterprises. Of this total width, people plantation has area width of 37.3 thousands hectares whereas plantation enterprises has area width of 166.7 thousands hectares (BPS-Kaltara 2020).

More specifically, the development of area width of oil palm plantation in North Kalimantan Province from 2019 to 2020 is depicted in Figure 1.

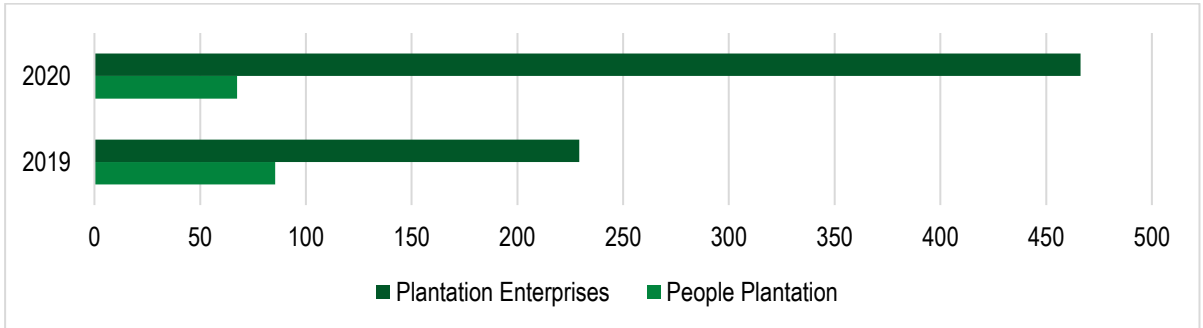
Figure 1. The Development of Area Width of Oil Palm Plantation in North Kalimantan Province, 2019-2020 (in thousand hectares)



Source: Secondary data are processed (2022)

Pursuant to the contents of Figure 1, the width of people plantation was a bit decreasing by 0.1% in 2019, precisely from 37.4 thousands hectares to 37.3 thousands hectares in 2020. Meanwhile, the area width of plantation enterprises has been increasing significantly by 41.23% from 118.06 thousands hectares in 2019 to 166.7 thousands hectares in 2020. Oil palm plantation enterprises play important role in the development of oil palm industry in North Kalimantan Province.

Figure 2. The Development of CPO Production in North Kalimantan Province, 2019-2020 (in thousand ton)



Source: Secondary data are processed (2022)

Oil palm industry processes oil palm into finished products and half-finished products which have higher economic value than their previous material. Among these products is Crude Palm Oil (CPO). The development of palm oil production in North Kalimantan Province from 2019 to 2020 is displayed in Figure 2.

Correspond to the content of Figure 2, CPO production of plantation enterprises increased significantly by 103.3% or 237 thousands tons from 229.2 thousands tons in 2019 to 466.2 thousands tons. Different from plantation enterprises, CPO production from people plantation decreased by 20.98% or 17.9 thousands tons from 85.4 thousands tons in 2019 to 67.5 thousands tons in 2020. This decrease is mainly caused by Covid-19 pandemic in 2020.

Following the data of plantation area width and CPO production, the potential of oil palm industry in North Kalimantan Province is quite promising but with the possible discharge of oil palm residues which include solid waste, liquid waste and gas (pollutant) waste. The elaboration regarding negative impact of oil palm waste on environment and society will be elaborated in the next sections.

3.2 Oil Palm Waste Management in North Kalimantan Province

Palm oil production leaves solid waste in the forms of empty bunch, fiber, shell and wet decanter solids. Liquid waste in the form of *sludge oil* has a characteristic resembling gelatin with blackish color. Gas waste is associated with methane, hydrogen and other air pollutant. Actually, in the context of North Kalimantan Province, oil palm waste has been managed to become other products with higher economic value. But the implementation of this processing is not yet optimally done by plantation enterprises and people plantation.

However, many plantation enterprises only utilize solid waste in small scale, or precisely only for the interest of themself. For instance, shell waste is used for hardening the access road to palm oil mills and very often used as the fuel of the boiler. Empty bunch is simply used as compost fertilizer for oil palm plantation. On the other hand, people plantation utilizes oil palm waste at household scale, which the products probably do not have high economic value as expected. Housewives of oil palm farmers groups in Tanjung Agung Village, Bulungan Regency, North Kalimantan Province have utilized the waste of oil palm leaf rib to make handicraft product named *Sa'ep* (Singal *et al.* 2021). Sa'ep is a term used by Dayak Kenyah Tribe in North Kalimantan Province to define plate or container made from plaited palm leaf rib. That is why the plate is called Rib Plate or *Piring Lidi*. Other enterprises related to oil palm plantation are not welcoming enough to the searching of information and data regarding their oil palm waste management. Therefore, in the current research, the information about management and utilization of oil palm waste are still limited.

3.3 Analyzing Negative Impact of Oil Palm Waste Perceived by Community

One of four goals that this research intends to attain is to find out the negative impact perceived by the community from oil palm waste. Following up this intention, sample was taken which the result is 50 respondents of dwellers who domicile at the vicinity of oil palm plantation enterprises. In majority, there are 94% respondents saying that oil palm waste from oil palm plantation enterprises is safe and not bringing negative impact on environment. Respondents who feel disturbed by oil palm waste are only 2%. Moreover, the negative impact of oil palm industry is also associated with the existence of garbage from production process.

There are three types of impact caused by oil palm waste, respectively water pollution, air polluton and soil pollution but the waste with the most prominent impact is air pollution, which is related with unpleasant smell. Respondents admitted that their health condition is interfered because their respiration system was disturbed by the smell. Air pollutant discharged by oil palm industry includes carbondioxide, carbonmonoxide, methane and other harmful gases (Anyaoha and Zhang 2021). Air pollutant (gas) is typically dust, smoke and gas emission from combustion process. Smoke usually emanates from boiler chimney, smoke stack of generator set and also as gas discharge from chemical reaction at the laboratory of oil palm plantation. Gas is air pollutant derived from the processing of frech fruit bunch (oil palm fruit after being removed from the bunch) into CPO (*Crude Palm Oil*) (Afifah *et al.* 2016a). Such disposed gas is very dangerous to the health of human or other living creatures.

3.4 Analyzing Economic Value Potential of Waste from Oil Palm Industry

Economic value of the waste from oil palm industry is the actual value of waste discharged by palm oil mills. The value of the marketed waste is called as direct use value while the value of the utilized waste is known as indirect use value. Before analyzing the economic value of the waste from oil palm industry, there is a notion that the utilized waste is dominated by:

a) Solid waste, which includes empty bunch, shell, fiber, and wet decanter solids.
b) Liquid waste, which refers to sludge oil.

As stated in previous section, every one ton of oil palm fresh bunch produces in average empty bunch waste for 220 kg (22%), fiber waste for 130 kg (13%), wet decanter solids [*lumpur sawit*] for 40 kg (4%), shell waste for 60 kg (6%), and sludge oil for 2 kg (0.2%) (Afifah *et al.* 2016b, Haryanti *et al.* 2014).

In pursuance of the 2020 data, CPO production in North Kalimantan Province was 528,700 tons. If this number is calculated from the amount of oil palm fresh bunch, then the involved bunch will be as much as 2,114,800 tons or 2,114,800,000 kg. The quantity of oil palm waste is presented in the following table.

Table 2. Quantity of Oil Palm Waste

Waste Type	Waste Proportion in Percentage	Waste Quantity per Year in Kg	Waste Quantity per Month in Kg
Shell	6	126,888,000	10,574,000
Sludge Oil	0.2	4,229,600	352,467
Empty Bunch	23	486,404,000	40,533,667
Fiber	13	274,924,000	22,910,333
Wet Decanter Solids	4	84,592,000	7,049,333

Source: Secondary data are processed (2022)

In accordance with the contents in Table 2, monthly revenue potential from marketed waste and non-marketed (utilized) waste is calculated. The result of this calculation is elaborated in the following table.

Table 3. Revenue Potential of Marketed and Utilized Oil Palm Waste

Revenue of Marketed Waste			
Waste Type	Price in IDR/kg	Waste Quantity (kg)	Revenue in IDR/month
Shell	500	10,574,000	5,287,000,000
Sludge oil	300	352,466,67	105,740,000
Total			5,392,740,000
Revenue of Non-Marketed (Utilized) Waste			
Waste Type	Price in IDR/kg	Waste Quantity (kg)	Revenue in IDR/month
Empty Bunch	50	40,533,667	2,026,683,333
Fiber	165	22,910,333	3,780,205,000
Wet Decanter Solids	25	7,049,333	176,233,333
Total			5,983,121,667
Total Revenue			11,375,861,667

Source: Secondary data are processed (2022)

According to the contents in Table 3, the total revenue potential of both marketed and utilized waste is IDR 11,375,861,667.00 per month. Revenue of marketed waste is higher than that of utilized waste because the marketed waste is affected by differences in sale price and waste volume. Price of shell and sludge oil is higher than price of empty bunch, wet solids and fiber. The difference in price seemingly affects the revenue level.

Net economic value of oil palm is estimated by calculating costs involved in the management and utilization of the waste. The costs consist of fixed cost and variable cost. Fixed cost comprises depreciation cost of waste production equipments, maintenance cost of waste production equipments, and workforce cost in waste handling. Variable cost is the cost that follows production volume. More detail about depreciation cost of waste production equipments is given in the following table.

Table 4. Depreciation Cost of Waste production Equipments

Waste Type	Equipment Type	Depreciation per Month
Empty Bunch	EFB Hopper	4,000,000
	EFB Conveyor	580,000
	Shredder	4,333,333
	Dumptruck	1,960,000
	Loader	1,764,333
Total		**12,637,666**
Fiber	Fiber shell conveyor	159,360
	Fuel Return Elevator	293,333
	Fuel Distibuting Conveyor	446,667
Total		**899,360**
Sludge Oil	Sludge collection pit	163,333
	Daily pond	216,667
	Cooling pond	200,000
Total		**580,000**
Shell	Fiber shell conveyor	6,640
	Loader	469,000
Total		**475,640**
Solid	Solid Bin	526,667
	Dumptruck	373,333
Total		**900,000**

Source: Secondary data are processed (2022)

Maintenance cost of dumptruck as a waste production equipment is shown in Table 5.

Table 5. Maintenance Cost of Dumptruck

Name of Equipment	Maintenance Cost	Cost of Empty Bunch	Cost of Wet Solids
Dumptruck	3,200,000.00	2,688,000.00	512,000.00

Source: Secondary data are processed (2022)

In conformity with the contents of Table 5, dumptruck maintenance cost is only incurred against empty bunch waste and wet solids because other waste does not use dumptruck. Workforce cost in waste management is explained in the following table.

Based on the contents of Table 6, total workforce needed for the management of oil palm waste is 1000 persons. The utilization of oil palm waste may need more than this number. Wage per day for this workforce is IDR 192,307.69 by assumption that the work day is 26 days in a month. Every worker will get monthly total income for IDR 5,000,000.00 (IDR 192,307.69 x 26 days). This wage level is much higher than minimum wage level in North Kalimantan Province. Correspond to the Decree of Governor of North Kalimantan Province No. 188.44/K.770/2021, minimum wage for North Kalimantan Province is IDR 3,016,738.00. Variable cost of oil palm waste production is presented in the following table.

Table 6. Workforce Cost of Waste Management

Waste Type	Number of Involved Workforce	Number of Work Day	Wage per Day (IDR)	Total Wage (IDR)
Empty Bunch	200	26	192,307.69	999,999,988.00
Fiber	200	26	192,307.69	999,999,988.00
Shell	200	26	192,307.69	999,999,988.00
Sludge Oil	200	26	192,307.69	999,999,988.00
Wet Decanter Solids	200	26	192,307.69	999,999,988.00
Total	1.000			4,999,999,940.00

Source: Secondary data are processed (2022)

Table 7. Variable Cost of Oil Palm Waste Production

Type of Cost Use	Variable Cost in IDR/Month	Cost of Empty Bunch (IDR/Month)	Cost of Shell (IDR/Month)	Cost of Wet Solids (IDR/Month)
Fuel for Loader	40,778,906.50	32,215,336.14	8,563,570.30	-
Lubricant for Loader	2,918,200.00	2,305,378.00	612,822.00	-
Fuel for Dumptruck	12,200,000.00	10,248,000.00	-	1,952,000.00
	Total	44,768,714.14	9,176,392.30	1,952,000.00

Source: Secondary data are processed (2022)

Pursuant to the contents of Table 7, the cost components of fuel for loader, lubricant for loader, and fuel for dumptruck are calculated when these equipments are used for handling empty bunch, shell and wet solids. By the costs determined for each waste, then economic value of processing and utilization of oil palm waste can be known. The acquisition of this economic value is elaborated in the following table.

Table 8. Economic Value of Oil Palm Waste Utilization

Direct Use Value					
Waste Type	Revenue	Total Cost	Profit/Loss Before Tax	Sale Tax (10%)	Economic Value
Cangkang	5,287,000,000	1,060,094,368.14	4,226,905,631.86	422,690,563.19	3,804,215,068.67
Sludge Oil	105,740,000	1,003,363,988.00	- 897,623,988.00	0	- 897,623,988.00
Total	5,392,740,000	2,063,458,356.14			2,906,591,080.67
Direct Use Value					
Empty Bunch	2,026,683.333	1,060,094,368.14	966,588,965.19	0	966,588,965.19
Fiber	3,780,205,000	1,000,899,348.00	2,779,305,652.00	0	2,779,305,652.00
Wet Solids	176,233,333	1,003,363,988.00	-827,130,654.67	0	- 827,130,654.67
Total	5,983,121,667	3,064,357,704.14	2,918,763,962.53		2,918,763,962.53
NET					5,825,355,043.20

Source: Secondary data are processed (2022)

In relation to the contents of Table 8, the economic value of oil palm waste utilization comprises direct use value and indirect use value. The former is the value of the waste that has been processed to be then sold in the market whereas the latter is the value of the waste that has been processed but not to be marketed or to be utilized for self-interest. Two waste have negative economic value, respectively sludge oil and wet solids. Total economic value of oil palm waste processing has positive value, which is described as profitable, as much as 5,825,355,043.20 per month.

Oil palm waste management in North Kalimantan Province will be potentially benefiting if the processing of oil palm waste is aimed for improving the living standard of workers, farmers and plantation enterprises. Waste management, either in the marketing or utilization, can absorb workforce, which therefore can reduce unemployment or help a lot of jobless individuals. Indeed, farmers groups and community members get wage in the waste-related jobs and use their income for improving their living standards.

3.5 Business Model for Utilization of Waste from Oil Palm Industry

Business model for oil palm waste utilization is constructed after conducting empirical review on previous studies. The result of this review indicates that there is an opportunity to create new entrepreneurs who will apply *green entrepreneur* concept (environmentally friendly entrepreneurship). Oil palm waste utilization can be done by farmers and community members through collaborative relationship with plantation enterprises. This collaboration is expected to produce a synergy across plantation entities in their efforts of improving the welfare of plantation farmers and community members, reducing environmental problem caused by plantation enterprises, minimizing negative impact of waste on environment, and anticipating the occurrence of social conflict due to waste issue.

The perception of farmers and community members concerning oil palm waste utilization is understood by conducting survey on 50 respondents (mostly village dwellers and farmers) who live nearby plantation enterprises, precisely in Ruhuy Rahayu Village, District of Tanjung Palas Tengah, Bulungan Regency, North Kalimantan Province. Respondents are required to give score to their perception based on the scale from 1 (very disagree) to 5 (very agree). The result of survey on oil palm waste utilization is displayed in the following table.

Table 9. Community Perception on Oil Palm Waste Utilization

Statement	Score Average
Oil palm waste must be processed before discharge in order to minimize the negative impact on environment.	4.73
Plantation enterprises must process their waste before discharge.	4.67
I am willing to cooperate with plantation enterprises in waste utilization efforts.	3.06
I am willing to self-dependently utilize waste produced by plantation enterprises.	2.88
I know how to utilize oil palm waste.	2.86
I am required to have specialized skill in waste processing.	4.16
The current generation must protect environment for the interest of the next generation.	4.80
Justness across generations must be the priority in policy making.	4.69
The impact of oil palm waste is already harmful to environment.	1.31

Source: Primary data are processed (2022)

In regard to the contents of Table 9, respondents who live nearby plantation enterprises have quite similar perceptions. Indeed, farmers and community members require plantation enterprises to manage their waste and control the waste processing to ensure that the waste products do not negatively affect environment and society. Besides, the respondents wish to have a cooperation with plantation enterprises in processing oil palm waste into other benefiting products. The problem is that farmers and community members lack of knowledge about how to process oil palm waste self-dependently. Therefore, the cooperation with plantation enterprises and the skill related to oil palm waste utilization are needed. Furthermore, the respondents also insist on protecting the environment in sustainable way for the interest of the next generation. Surprisingly, the respondents perceive that oil palm waste from oil palm enterprises is safe and never bringing negative impact on environment. This posture was confirmed by 94% respondents who said that oil palm waste from oil palm plantation enterprises do not give negative impact on environment and never disturb environment, particularly their dwellings.

The activity that has been carried out by farmers and community members concerning the management and utilization of oil palm waste, their readiness for this utilization and their cooperation with plantation enterprises, are shown in the following table.

As indicated by the contents of Table 10, farmers and community members do not quite understand about how to process oil palm waste and also do not have the required skills. On the other hand, farmers and

community members somehow realize that oil palm waste can be utilized. The problem is that farmers and community members do not yet take initiative to build cooperation with plantation enterprises or other institutions. In consequence, the economic potential of oil palm waste cannot be yet managed optimally.

Table 10. Condition and Readiness of Farmers/Community Members Toward Oil Palm Waste Management

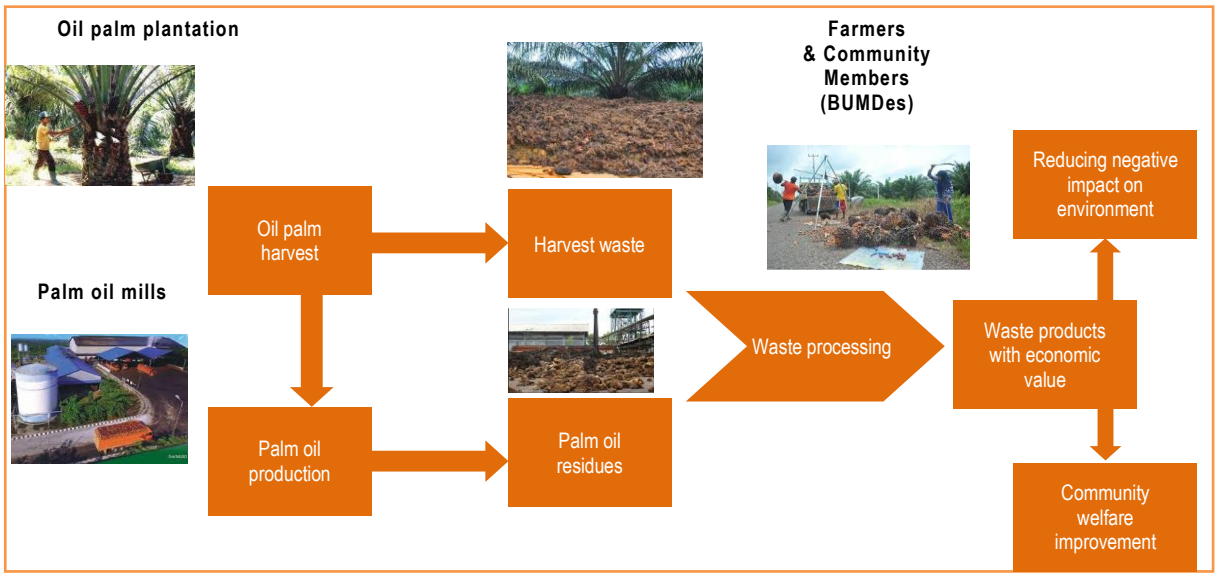
No	Statement Item	Actual Condition
1.	Type of waste that has been ever utilized	90% respondents said that there is no oil palm waste that needs to be processed. 10% respondents have processed waste, which the waste is in the form of empty bunch and wet decanter solids.
2.	Quantity of waste that has been ever produced	90% respondents never encounter the waste. 10% respondents ever processed waste in weight of ¼ to 1 ton.
3.	Technology used in waste processing	90% respondents never use any technologies. 10% respondents use manual and simple technologies.
4.	Product from oil palm waste	90% respondents reported that there is no products from the waste. 10% respondents admitted that the product is mostly in the form of compost fertilizer.
5.	Cooperative relationship with plantation enterprises	90% respondents informed that there is no cooperation with plantation enterprises. 10% respondents notified that there is relationship across the suppliers of fresh fruit bunch, employees of plantation enterprises, oil palm buyers and oil palm couriers.
6.	Training about oil palm waste management	96% respondents never attend the training. 4% respondents get the related training from seminar and in their higher education.
7.	Receiving helps for oil palm waste management	100% respondents never get such helps.
8.	Understandings about oil palm waste utilization	99% respondents feel quite informed about oil palm waste utilization but do not do the processing. 1% respondents do not know how to utilize oil palm waste.
9.	Skills needed for oil palm waste processing	88% respondents do not have relevant skills. 8% respondents have technical skills. 4% respondents have marketing skills.
10	Trusted party to mitigate the risk of oil palm waste	49% respondents refer to government or authorized party. 44% respondents believes in Village Enterprise (BUMDES). 7% respondents rely on farmers groups

Source: Primary data are processed (2022)

The initiative toward collaboration among farmers groups, community members, government, Village Enterprise (Bumdes), and plantation enterprises in oil palm waste utilization in North Kalimantan Province is truly needed. The result of analysis on economic value reveals that oil palm waste utilization has benefited plantation enterprises and also been helpful in absorbing workforce and improving the income of farmers and workers.

Referring to the opinion given by Utomo *et al.* (2021), the utilization of oil palm waste by plantation enterprises shall involve farmers and community members in order to create new entrepreneurs who are environmentally friendly and who are able to implement waste processing, to make the processing more efficient and to implement recycle system. Indeed, the collaboration between farmers, community members, and plantation enterprises in managing and utilizing waste into economically valuable products is then formulated in this research within a business model. This model is described in Figure 3.

Figure 3. Business Model of Oil Palm Waste Utilization



Source: Utomo *et al.* (2021)

As illustrated in Figure 3, oil palm waste emanates from 2 sources. **First** source is oil palm waste from harvest in oil palm plantation owned by state, private and local people. **Second** source is oil palm waste derived from palm oil residues (from palm oil mills). Both sources can be directly managed by farmers and community members into new processed products. Sometimes, palm oil mills and also oil palm enterprises hand over the residues (waste), which are not yet utilized, to farmers groups and community members to be further processed. By such generosity, palm oil mills get benefit in the form of reducing environmental cost of waste processing. On the other side, farmers groups and community members get benefit in the form of acquiring additional income from waste processing. Moreover, the environment becomes cleaner because oil palm waste has been well utilized through recycle or reprocessed into other products with economic value. Such arrangement can prevent social conflict in relation with waste. In the business model proposed by this research, farmers group and community members as the waste processor are represented by an institution called Village Enterprise (BUMDES-*Badan Usaha Milik Desa*). According to Law No. 6 of 2014 and Government Regulation No. 43 of 2014, BUMDES was founded by intention to implement economic empowerment program at village level. The creation of BUMDES will accommodate local economic potentials that can stimulate and improve village economic (Purnamasari 2015).

Conclusion

This research is aimed to identify the potential economic value of oil palm waste utilization and to construct a business model based on oil palm waste utilization for the context of North Kalimantan Province. Based on the data regarding area width and CPO production, the potentials of oil palm industry in North Kalimantan Province are quite promising but also producing residues in the forms of solid, liquid and gas (pollutant). Plantation enterprises, plantation farmers and community members do not yet optimally manage, utilize and change oil palm production waste into other products with economic value. Oil palm waste is simply used as compost fertilizer because this utilization does not need further processing. The majority dwellers who live in vicinity of plantation enterprises have perceived that oil palm waste from oil palm enterprises is safe and never bringing negative impact on environment. Only few dwellers feel disturbed by oil palm waste. Negative impact of oil palm waste is only related with the amount of garbage which increases quickly with the establishment of oil palm industry.

Economic value potential of oil palm industry leads to positive or profitable economic value. The management of oil palm waste in North Kalimantan Province can potentially benefit plantation enterprises, plantation farmers, and community members who live nearby plantation area. Waste management can also absorb workers which then reduces unemployment. Workers and community members can get additional income beyond their usual livelihood from main product of oil palm industry, which is Crude Palm Oil (CPO).

Concerning with the real condition of oil palm waste management, farmers and community members have realized that oil palm waste can be utilized but either farmers or community members do not yet take initiative to build cooperation with plantation enterprises or other institutions. This decision makes the economic potential of

oil palm waste become less optimally managed. Dealing with this issue, the initiative toward collaboration among farmers groups, community members, government, Village Enterprise (Bumdes), and plantation enterprises in oil palm waste utilization in North Kalimantan Province is necessary. Business model of oil palm waste management is then proposed and this model is involving farmers and community members who are represented by Village Enterprise (Bumdes). This involvement is in line with the intention to create new entrepreneurs who are environmentally friendly. The suggested business model benefits plantation enterprises through the reduction of environmental cost from waste processing whereas the farmers and community members benefit from the model through additional income acquired from waste processing. Clean environment is obtained by processing oil palm waste through recycle or by reprocessing the waste into other products with economic value. The utilization of oil palm waste can prevent social conflict concerning waste from happening.

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Credit Authorship Contribution Statement

Mohamad Nur Utomo: conceptualization, investigation, methodology, software, formal analysis, writing – original draft, supervision, data curation, validation, writing – review and editing, funding acquisition.
Ahmad Mubarak: conceptualization, supervision, visualization, validation
Sulistya Rini Pratiwi: conceptualization, investigation, methodology, project administration, writing – original draft, supervision, data curation, validation, writing – review and editing.
Najmudin Najmudin: conceptualization, investigation, supervision

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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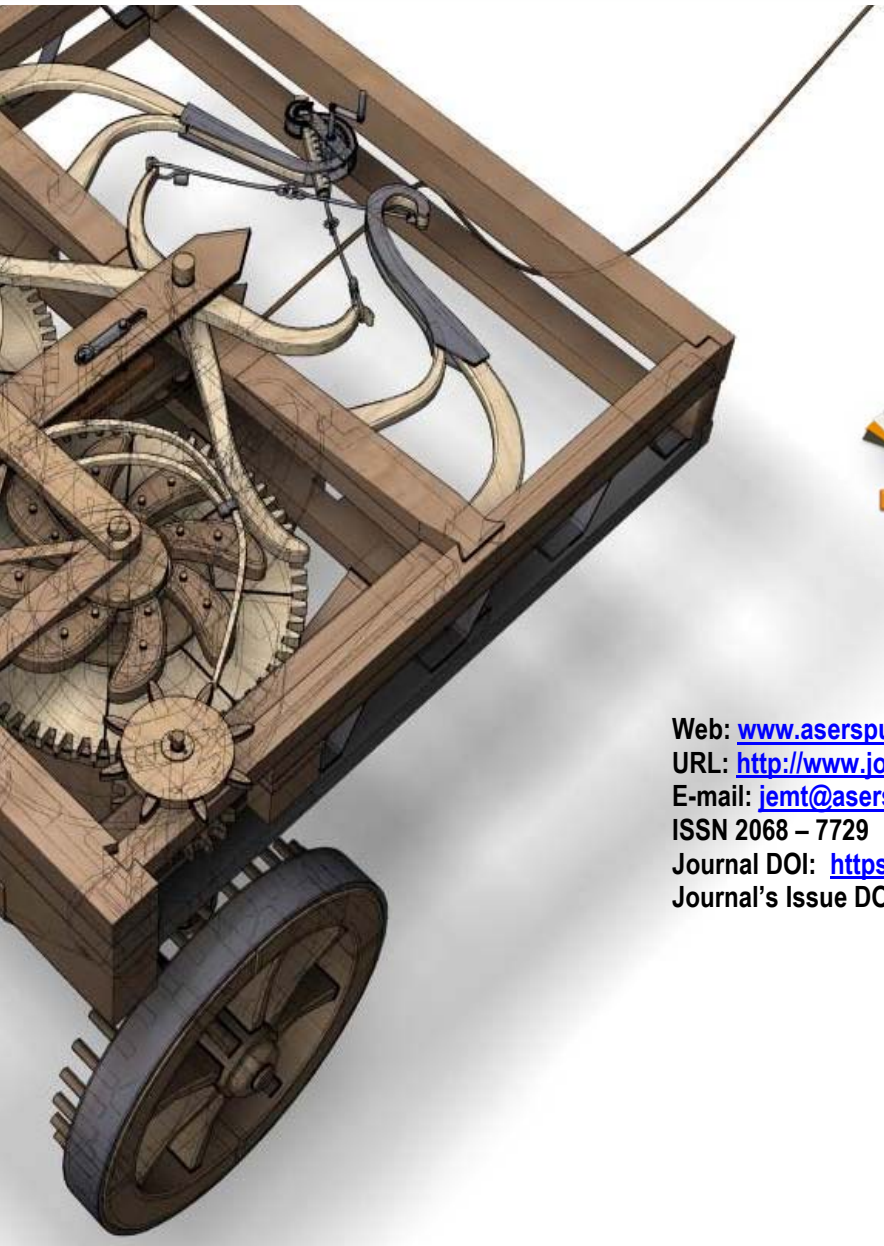

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