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Sustainable oil palm industry: The possibilities

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ABSTRACT

Cruel oil or green gold is a dilemma for the oil palm industry. The oil palm industry (planting and milling) has a devastating impact on the environment and ecosystems. Oil palm plantations and expansion cause deforestation, habitat loss, forest fragmentation, biodiversity loss, food chain disruption, soil property changes, water and air pollution, conversion of wetlands and arable lands, and increased greenhouse gas (GHG) emissions, resulting in annual fires as well as increasing both subsidence and flood risk. Palm oil mill effluents (POME) are toxic compounds that cause eutrophication and acidification, pollute terrestrial and aquatic systems and release greenhouse gases. However, the oil palm industry is a million-dollar industry that ensures food security (oil and fat). There is increasing demand for palm oil due to population growth and for use as a biofuel feedstock. Significant higher production per hectare in comparison to other oil crops is the main advantage of oil palm. The anthropogenic pressure on the environment is increasing to fulfil the demand and increasing susceptibility to natural disasters. Therefore, the sustainability of this industry is an urgent need. This critical review identified gaps and researched ways for the oil palm industry to be sustainable. Maintaining ecological integrity (ecological health, connectivity, resilience); justifying land allocation (ecosystem service mapping); providing awareness, good management practices, no/minimum production gaps, high yield and disease resistant cultivar generation and plantations, supplemental forms of alternative sources, zero-waste milling technology; and locating plantations on suitable land without further deforestation can fulfil the oil palm industry's present and future demands without impairing the ecosystem or environment.

1. Introduction

An ecosystem is a complex composition of physical, chemical and biological components. The ability of an ecosystem to support and maintain biological communities (assemblages of species) comparable to those found in unmanaged or relatively undisturbed habitats of the region is recognized as Ecological Integrity. Ecological Integrity includes biotic (living things) and abiotic components (soils, air, water) as well as ecosystem functions, such as energy flow and nutrient cycling, within the forest. A complex ecosystem remains in a healthy state if the ecological integrity and resilience is maintained [1]. Ecosystems provide various goods and services to society, which in turn directly contribute to human well-being and economic wealth [2,3]. Ecosystem services are defined as the contributions of the ecosystem structure and function in combination with other inputs to human well-being [4]. Human survival and well-being depends on these services and therefore on the conservation and best management of the ecosystems that provide them. The ecosystem services concept has been postulated as having important potential to support land use planning [5]. Ecosystem services mapping and analysis facilitates trade-off analysis [6] and can also be used to optimize the allocation of land for specific uses [7].

Oil palm is economically important crop that ensures food security. Recently, it has emerged as a potential source of renewable energy [8–10]. In 2015, the world oil palm production reached 55.70 million tons (MT) from 17.32 million hectares (mha) of plantation. The average production is 3.214 t/ha (FAOSTAT[1]). Due to population growth and increased energy demand, the demand for oil palm is increasing. Global palm oil production has doubled every 10 years in the past few decades. By 2020, the production is expected to reach 78 million tons

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[1] http://faostat3.fao.org/browse/Q/QC/E, Last Accessed Jun, 2016.

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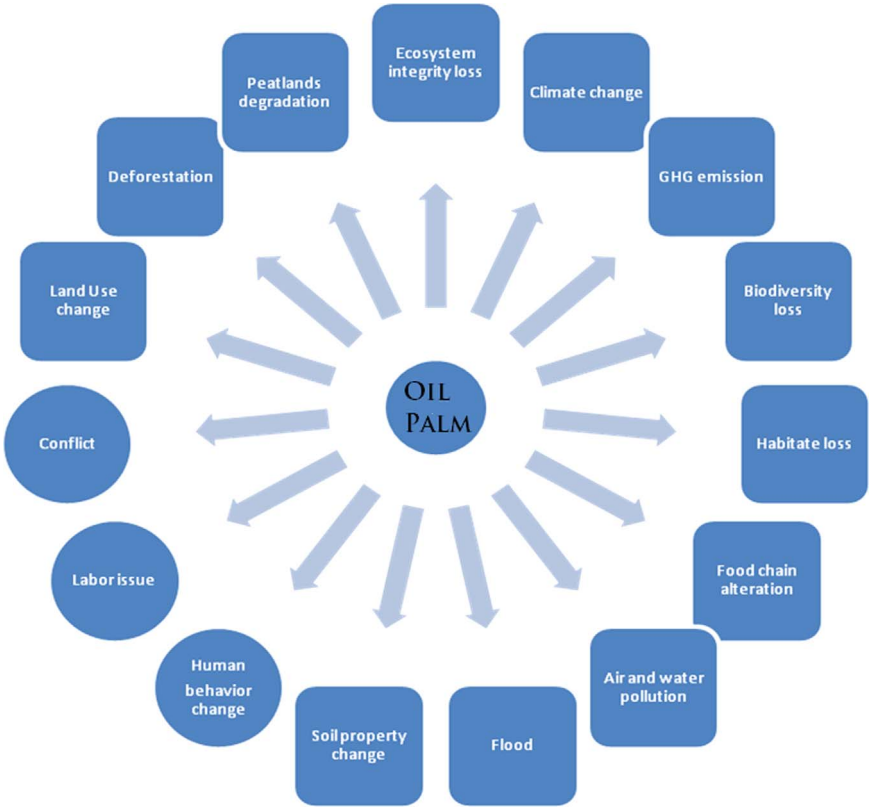

Fig. 1. Environmental and social impact of oil palm plantation.

[11]. The increased demand is expected to lead to the expansion of oil palm plantations. With the current (2015–2016) production rate, a plantation increase of approximately half of the existing plantation area is required to fulfil the demand needed by 2020. However, traditional oil palm plantations and expansion are detrimental to the environment, especially tropical forest, as they cause deforestation [12,13], habitat loss [13], forest fragmentation [14], biodiversity loss [15], food chain disruption, soil property changes [16,17], water and air pollution [12,18], conversion of peatlands [19] and arable lands [20], and increased carbon dioxide (CO_2) emissions [21,22], resulting in annual fires [22] as well as increased subsidence and flood risk (Fig. 1). Palm oil mill effluents (POME) are eutrophying, acidifying, and toxic compounds that pollute terrestrial and aquatic systems [23] and release greenhouse gases [24]. The conflicts over land rights [25], labour management [26], human behaviour change [27] and the livelihood (low income) of smallholders are social issues related to plantations.

The economy, environment and society are the basis of sustainable development. Oil palm is an important and large industry. Oil palm plantations and expansion are of great concern for environmentalists, ecologists and policy makers. Therefore, the sustainability of this industry is critical. We critically studied environmental issues and supply-demand issues along with technological improvement and application towards sustainable oil palm industry. Finally, we explored the gaps that need to be sealed as well as ways to make the oil palm industry sustainable.

2. Oil palm as a promising renewable energy source

The world energy spending will have increased three fold by the last 50 years ending in 2025. Till date fossil fuel is contributing to over 80% of the total combusted energy. The fossil fuel oil is expected to face a greater threat of becoming exhausted. Globally the maximum oil production may likely be between 2015 and 2030. It is then expected to sharply decline to 40% of today's production by 2075 [28]. Industrialisation, economic growth, global warming, energy security sustainable environment and comfortable life are the challenges of modern civilisation. To fulfil the above, the world is looking for adequate renewable energy sources [29].

The use of vegetable oils as an alternative fuel has been reported. Oil from rapeseed was the first type used for bio-diesel production and it remains the main feedstock for bio-diesel production in Europe [30]. However, the best alternative fuel must be environmentally acceptable, technically feasible, economically competitive and readily available. Oil palm is a high yielding oil crop. On an average, it produces up to 10 times higher yield in comparison to other oil crops (soybean, sunflower, rapeseed) [31]. Among the vegetable oil sources, palm oil is a cheap option for bio-diesel feedstock [32]. Moreover, palm oil can easily be converted to bio-diesel [9,33].

Generally, bio-ethanol is produced from sugar or starch grains by fermentation. Solid waste from oil palm, especially empty fruit bunch (EFB), contains higher sugar. Glucose and xylose were successfully produced from EFB [34,35]. Pyrolysis and fermentation or hydrolysis of EFB can produce bio-oil and bio-ethanol. Bio-methanol is also produced from biomass. Black liquor gasification is a cost competitive technique to produce methanol from biomass.[2] Trunk of oil palm can produce black liquor [36,37].

Biomass can also be used to generate bio-powers [38–40]. Direct-fired, gasification, anaerobic digestion, pyrolysis, and small, modular systems are different forms of bio-power. Direct firing of solid waste (EFB, mesocarp fibre) can produce heat and steam for ultimate electricity production [26]. Synthesis gas, also known as syngas, produced from biomass materials has been identified as a potential source of renewable energy for power generation and transport fuel, as

[2] Institute for the Analysis of Global Security. /http://www.iags.org/n052404t3.htmS (Accessed August 2016).