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Time to Revisit Oil Palm-Livestock Integration in the Wake of United Nations Sustainable Development Goals (SDGs)

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To date, the idea of using livestock animals as biological tools to manage weeds, sequester carbon, and boost food security in oil palm plantations has not been seriously considered by industry stakeholders of major producing countries (e.g., Indonesia, Malaysia, Thailand, Colombia, and Nigeria). We revisit the integration of oil palm cultivation with livestock farming as a silvopastoral agroforestry practice in the wake of Sustainable Development Goals (SDGs). Oil palm-livestock integration has the potential to promote sustainable palm oil production because it can provide multiple environmental and socio-economic benefits, including carbon sequestration, restoring top soil, improving ecosystem biodiversity, reducing pesticide and fertilizer inputs, and boosting national food security. In contrast to monocultural outputs of most conventional plantations, an oil palm silvopastoral system is an ideal way to address the global food insecurity challenge as it produces bioenergy, vegetable oil/fat and animal-based protein sources (e.g., red meat). In addition, the potential of contract targeted grazing could be considered as a new type of business and income diversification for rural people. Oil palm-livestock integration is a strategy by the palm oil industry to achieve multiple SDGs. Out of the 17 SDGs, oil palm-livestock integration is likely to deliver nine SDGs. Palm oil certification bodies should recognize oil palm-livestock integration as a biological control method in weed management practices. We recommend that oil palm-livestock integration should be promoted to revitalize sustainable palm oil production and strategic biodiversity conservation policy. Policy makers should encourage major players in the palm oil industry to practice oil palm-livestock integration.

Keywords: biodiversity, carbon sequestration, palm oil certification, targeted grazing, food security, weed, pesticide

INTRODUCTION

Conventional agricultural practices in oil palm plantations need to undergo major transformations to meet the United Nations Sustainable Development Goals (SDGs) by 2030 (Eyhorn et al., 2019). Oil palm agriculture has been controversial in terms of its environmental and social sustainability and thus the industry has been required to make transformations to its current agricultural practices (Austin et al., 2017; Azhar et al., 2017). The controversy oil palm agriculture draws internationally, is commonly a social and ecological justice narrative of criticism about the destruction of forest landscape and its biodiversity (Corciolani et al., 2019; Pye, 2019; Gatti and Velichevskaya, 2020; Qaim et al., 2020; Ramdani and Lounela, 2020). Because oil palm industry substantially contributes to the economic prosperity and the alleviation of rural poverty in major producing countries (e.g., Indonesia and Malaysia), the industry deserves an opportunity to improve its environmental and social sustainability, similar to those given to other commodity crops (e.g., cacao and coffee) (Donald, 2004; Azhar et al., 2017, 2021; Qaim et al., 2020; Mehraban et al., 2021).

To date, oil palm stakeholders have paid little attention to improving agricultural practices to better reconcile palm oil production with biodiversity conservation, and the socio-economic concerns (Azhar et al., 2015a, 2017). Industrial oil palm cultivation is highly dependent on fossil fuel energy and external nutrient and chemical inputs. For instance, to control weeds in oil palm plantations, commercial growers rely heavily on the application of chemical herbicides (e.g., broad-spectrum glyphosate-based herbicides) which can pollute the environment and indiscriminately eliminate non-target or beneficial species (Shariff and Rahman, 2008; Choo et al., 2011; Singh et al., 2014; Tayeb et al., 2017; Dilipkumar et al., 2020; Pochron et al., 2020). Oil palm-livestock integration through targeted or prescribed grazing approach (i.e., the application of livestock grazing to attain specific vegetation management goals such as enhancing desirable plant communities and controlling invasive plant populations) can substitute herbicide use for weed management (Frost and Launchbaugh, 2003; Tohiran et al., 2017, 2019a; Bailey et al., 2019). However, this is regarded as an unpopular practice among oil palm growers because of the additional workload (e.g., managing livestock animals) and outstanding social challenges (e.g., livestock theft, animal trespassing onto private properties) (**Figure 1**; Tohiran et al., 2017, 2019a). In conventional oil palm plantations, chemical herbicides are used 2–3 times annually to control weed growth and minimize plant competition for soil nutrients (Jalaludin, 1996; Tohiran et al., 2017, 2019a). Alternatively, livestock animals such as cattle, buffalo, sheep, and goats can exploit at least 60 weed species (Jalaludin, 1996). The cost of weeding is quite substantial (i.e., ranging from 17 to 38% of operational costs) and can be reduced if the forages in the inter-rows and harvesting paths are grazed and/or browsed by livestock animals (Jalaludin, 1996; Devendra and Thomas, 2002; Latif and Mamat, 2002).

In Malaysia, the integration of oil palm cultivation with livestock farming has been promoted by the Malaysian Palm Oil Board (MPOB) since 2000. The integration programme is

FIGURE 1 | Conventional oil palm plantation and oil palm-livestock integrated plantation. To improve the environmental sustainability of oil palm industry, commercial growers can switch from spraying chemical herbicides (**top left**) to targeted livestock grazing (**top right**). Mixed species grazing which combines two or more ruminant species with different foraging strategies (grazer or browser) can be integrated into weed management in industrial oil palm plantations. For example, goats and sheep are browsing and grazing ruminant, respectively (**bottom**).

primarily implemented to provide additional income to oil palm growers via production of animal-based proteins (Devendra, 2009, 2011; Ismail et al., 2014; Zamri-Saad and Azhar, 2015). Generally, the integration can optimize the use of agricultural land area. Instead of producing solely palm oil, the same agricultural land space can also be used to produce beef for domestic markets.

The oil palm-livestock integration practice can provide an alternative source of revenue to commercial oil palm growers, either to plantation companies or smallholders, especially when the market price of palm oil is low (Latif and Mamat, 2002; Tohiran et al., 2014, 2017; Silalahi et al., 2019). However, the potential of integrating oil palm and livestock production appears not to have been seriously considered by major palm oil stakeholders and policy-makers to address global challenges such as climate-change, carbon farming, certification, food security, and SDGs; this, despite growing evidence suggesting oil palm-livestock integration is crucial to help ensure regional food security in the future, while promoting agroforestry silvopastoral systems that reduce the expansion of cropland and pasture areas (Devendra, 2011; Zamri-Saad and Azhar, 2015; Azhar et al., 2017).

This paper aims to highlight the importance of oil palm-livestock integration toward achieving SDGs in the wake of various global challenges. We suggest oil palm-livestock integration practices as a novel tool that can help address these significant challenges of the globalized human community. In this paper, we consider how oil palm-livestock integration can provide multiple socio-economic benefits by establishing biological weed control through targeted grazing or rotational grazing systems, improving the well-being and livelihood of local people, and protecting the wider biophysical environment. We hope this paper can inform palm oil industry stakeholders and government policy makers to include oil palm-livestock integration as a new strategy to bolster palm oil sustainability.

ADDRESSING THE SDGs THROUGH OIL PALM SILVOPASTORAL SYSTEM

Oil palm-livestock integration is likely to deliver 9 out of the 17 SDGs (**Table 1**; **Figure 2**). In general, the aim of SDGs is to end hunger, eliminate extreme poverty, reduce inequality, tackle climate change, halt the loss of biodiversity and ecosystems, and promote sustainable agriculture by 2030 (United Nations, 2020). Oil palm-livestock integration can contribute substantially toward meeting SDGs as it can ensure resilient agriculture and agro-biodiversity (Tohiran et al., 2017, 2019a,b).
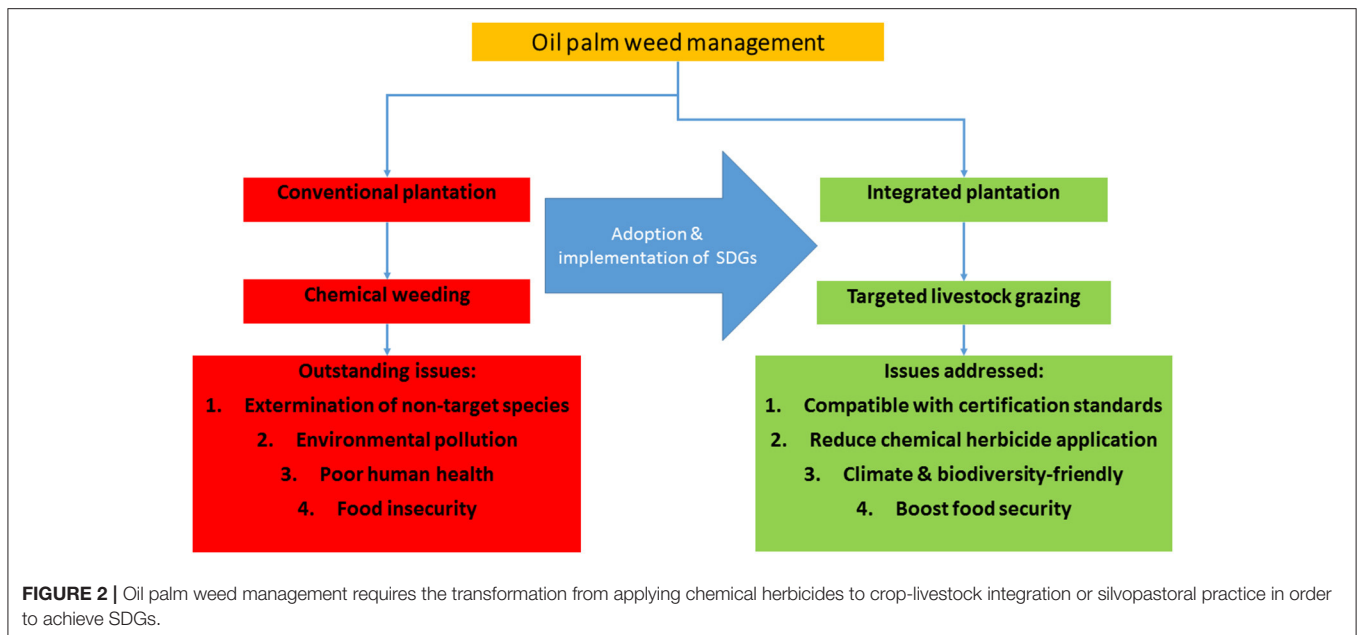
The integration of palm oil production with livestock grazing known as silvopastoral practice provides multiple benefits such as carbon sequestration, restoring topsoil, improving ecosystem biodiversity, and reducing pesticide and fertilizer inputs (Herrero et al., 2010; Wright et al., 2012; Lemaire et al., 2014; Azhar et al., 2017; Tohiran et al., 2017, 2019b; Hoosbeek et al., 2018; Tarbox et al., 2018) (**Table 1**). Oil palm-livestock integration can introduce silvopastoralism (i.e., grazing under substantial tree cover) into the historically myopic, monocultural oil palm industry, providing ecological conditions that considerably increase potential for conserving biodiversity. Livestock animals can be effectively used as biological control agents to manage weeds in oil palm plantations, which aligns directly with palm oil certification schemes of the Roundtable on Sustainable Palm Oil (RSPO) and Malaysia Sustainable Palm Oil (MSPO) to recommend growers to reduce the practice of agrochemical weed control. Tohiran et al. (2017, 2019b) demonstrated how the level of conservation benefits, derived from oil palm-livestock integration practice, may vary depending on the type of integration system (e.g., systematic rotational grazing and free-range grazing).

When properly managed under the right conditions (i.e., appropriate stocking density and duration), livestock grazing integrated with tree crops can mitigate soil degradation and restore healthy ecosystem functioning, locking carbon deep in the ground (Sanderson et al., 2013; Rivera-Ferre et al., 2016; Brewer and Gaudin, 2020). Silvopastoralism can sequester tons of carbon per hectare per year, making it one of the most effective carbon-storing tools in agriculture, thereby helping mitigate greenhouse gas (GHG) emissions (Torres et al., 2017; López-Santiago et al., 2019; Brewer and Gaudin, 2020; Ribeiro et al.,

TABLE 1 | Potential benefits of oil palm-livestock integration and expected SDGs outcomes.

Benefits	Details	SDGs outcomes
Ecology	1. Reduce the use of chemical herbicides as well as water contamination.	SDG 6: Clean water and sanitation SDG 12: Responsible consumption and production SDG 13: Climate action
	2. Maintain key vegetation structure for various animal species.	SDG 15: Life on land
	3. Maintain floristic diversity.	SDG 15: Life on land
	4. Reduce bare ground and soil erosion.	SDG 15: Life on land SDG 13: Climate change
	5. Improve soil biodiversity and fertility (e.g., soil organic matter from animal dung, dung beetles improve soil aeration and increase soil organic matter).	SDG 15: Life on land
	6. Promote green practices that apply less chemical solutions leading to a smaller carbon footprint through well-managed cattle grazing practices.	SDG 13: Climate action
	7. Sequester soil carbon in oil palm silvopastoral systems to mitigate atmospheric greenhouse gas emissions.	SDG 13: Climate action
Economy	1. Additional revenue from beef/meat production.	SDG 1: No poverty SDG 2: Zero Hunger
	2. Cut chemical weeding costs for mature oil palm fields.	SDG 9: Industry, innovation and infrastructure
	3. Boost national food security.	SDG 2: Zero hunger
	4. Create new jobs and entrepreneurship opportunities (e.g., targeted grazing contractors).	SDG 1: No poverty SDG 8: Decent work and economic growth SDG 9: Industry, innovation and infrastructure
Social	1. Guarantee the health of workers/growers by reducing the risk from herbicide-related illnesses (e.g., cancer).	SDG 3: Good health and well-being

2020). Although livestock animals such as cattle are the largest contributor to agriculturally-sourced greenhouse gas emissions (Rivera-Ferre et al., 2016; Bogaerts et al., 2017), research investigating carbon sequestration by oil palm-livestock systems as a potential solution to excessive greenhouse gas emissions in oil palm producing countries is needed. Furthermore, oil palm-livestock integration can potentially reduce forest clearance for conversion to new pasture and cropland as integrating livestock farming within existing oil palm plantations means they are jointly-used as grazing areas and croplands. This practice also reduces the application of chemical herbicides, which can subsequently enhance biodiversity conservation (Slade et al.,

FIGURE 2 | Oil palm weed management requires the transformation from applying chemical herbicides to crop-livestock integration or silvopastoral practice in order to achieve SDGs.

2014; Tohiran et al., 2017). Additionally, oil palm growers can save fertilizer money as livestock integration promotes incorporation of organic matter into the soil due to animal feces deposition and trampling (Ávila-Ramírez et al., 2019).

TARGETED GRAZING MANAGEMENT IN OIL PALM SILVOPASTORAL SYSTEMS

Not only could oil palm-livestock integration reduce agricultural greenhouse gas emissions, it could also contribute to rural economic development. Integrating livestock animals into oil palm farming operations can bestow low-capital business opportunities (Hatfield et al., 2006). Plantation companies or smallholders can incorporate oil palm-livestock integration using targeted grazing practices as part of their operation, to diversify their business profile and thus boost revenue. Targeted grazing is the application of a particular kind of grazing animal, for a specified duration and stocking level to purposely exert grazing/browsing pressure on specific plant species or portions of the landscape (Frost et al., 2012; Bailey et al., 2019). In oil palm plantations, the stocking density proposed for cattle is 30–35 animal units per 125 ha and cattle are moved systematically to a new silvopasture plot every three days (Tohiran et al., 2019a; Azhar et al., 2021). Besides cattle, other livestock species (e.g., buffalo, sheep, goat or mixed-species grazing) can be integrated with palm oil cultivation (Azhar et al., 2021). This may necessitate further study to measure the suitable stocking density and stocking day because livestock integration with palm oil agriculture relies on soil type and topography of a particular plantation (Azhar et al., 2021).

Integrated oil palm-livestock systems can financially benefit local businesses and bring economic prosperity to rural areas in oil palm-producing countries (Latif and Mamat, 2002;

Wulandari, 2021). Oil palm-livestock integration can improve rural food security and livelihood generation as rural areas depend significantly on crop agriculture and livestock production (Herrero et al., 2010; Wright et al., 2012; Thornton and Herrero, 2014). Oil palm plantation operators unwilling to keep livestock for targeted grazing for their own weed management practices could instead hire businesses or grazing contractors that maintain livestock animals for specific targeted grazing for weed management purposes. This would create new job opportunities and entrepreneurs who offer targeted grazing services to clients, particularly in rural areas (**Table 1**).

Targeted grazing services on a contractual basis is a very different business model than simply grazing for livestock production. Traditional livestock production focuses on putting weight on animals or increasing reproductive success and generating income through the sale of animals and animal products (Launchbaugh et al., 2006). On the other hand, targeted grazing contractors can generate incomes by providing weed management services; these businesses may tolerate a drop in body condition or reproductive success to achieve desirable targets of reduced cover of low quality forage as long as this service is paid for (Hatfield et al., 2006; Launchbaugh et al., 2006; Macon, 2014). Targeted grazing operators need to understand plant physiology, plant structure, plant growth patterns, and plant species' palatability/toxicity cycles in oil palm silvopastoral systems (Kott et al., 2006; Launchbaugh et al., 2006; Frost et al., 2012; Macon, 2014).

DISCUSSION

Targeted grazing is a cost-effective weed management alternative, especially on landscapes that are too steep, rocky, remote or large for conventional weed management (like mowing or chemical treatment). Grazing plans, livestock animal density, and grazing

duration are important components that influence the ability of livestock animals to reduce the abundance of weeds (James et al., 2017). Herbicides are effective to control weeds, but expensive (Bailey et al., 2019). Shariff and Rahman (2008) reported that oil palm growers sprayed 7 to 14 liter of mainly glypohasate-based herbicides per hectare annually (current price is approximately MYR19 per liter). For a typical oil palm plantation in Peninsular Malaysia (average area is ∼2,200 ha) (Azhar et al., 2011), between 15,400 and 30,800 liter of herbicides are used to control weeds, costing each plantation around MYR 300,000–600,000 every year. Alternatively, targeted grazing would substantially cut down the use of such herbicides from 75 sprayings in a single planting cycle (25 years) down to 15 sprayings (Tohiran et al., 2017). This positively improves biodiversity conservation and ecosystem services (e.g., pest control by beneficial birds and insects) in oil palm plantations (Tohiran et al., 2017; Razak et al., 2020).

Big ruminants such as cattle and buffalos can be kept in oil palm plantations without housing in permanent barn structures, whereas small ruminants such as goats and sheep need to be housed overnight (Wahid et al., 2010; Tohiran et al., 2014). Electric fencing systems can be used to contain the movement of livestock animals and thus concentrate grazing pressure in defined areas for a set duration of time. Only mature oil palm fields (aged more than 6 years) are suitable for the integration with livestock because young palms are vulnerable to damage from grazing and browsing (Tohiran et al., 2017; Azhar et al., 2021). Approximately 13 million ha of mature oil palm fields were available in 15 major oil palm producing countries (Azhar et al., 2021).

Oil palm production landscapes (either industrial plantations or smallholdings) are the major agricultural matrix which encompasses forest patches and shares boundary with protected areas (e.g., national parks or nature reserves) (Azhar et al., 2015a,b). In terms of landscape connectivity, by creating a herbicide-free oil palm matrix or at least applying less herbicides, oil palm plantations and smallholdings can be more hospitable to biodiversity, particularly for visiting forest species to move between plantations and forest patches and/or protected areas.

Ideally, mixed species grazing systems can also be implemented when two or more ruminants graze together in oil palm plantations (Fraser and García, 2018). Body size and anatomical differences between ruminant species are reflected in diet selection and foraging behavior, which can be used to successfully manage weeds in oil palm plantations (Fraser and García, 2018). For example, cattle and goats can be combined into an effective grazing unit to control different weeds such as grasses and shrubs. Otherwise, using cattle grazing alone without the browsing foraging pattern of goats, would successfully suppress the grasses but leave resident shrub species relatively unaffected in oil palm plantations (Tohiran et al., 2014, 2017, 2019a). In this manner, livestock grazing and browsing can replace circular herbicide spraying at the base of oil palms and spot spraying on shrubs. Commercial oil palm growers with cattle can obtain greater weight of meat per hectare and can reduce weeds and unwanted shrubs in a plantation when adding small ruminants for mixed species grazing systems (Devendra

and Thomas, 2002; Devendra, 2011; Zamri-Saad and Azhar, 2015; Tohiran et al., 2017).

Oil palm-livestock integration is a promising silvopastoral practice that should be promoted and upscaled to deliver greater environmental and socio-economic benefits in tropical zone countries (Devendra, 2009; Tohiran et al., 2014; Azhar et al., 2017, 2021). Oil palm-livestock integration has the potential to reduce poverty, improve livelihoods of small-scale crop–livestock farmers, and thus encourage national economic growth of oil palm-producing countries. Oil palm-livestock integration offers plantation stakeholders and policy decision-makers one possible route for implementing change toward achieving the UN SDGs, particularly in addressing environmental pollution (from agrochemical application), biodiversity conservation, poverty, and climate change mitigation.

Well-managed grazing ruminants in oil palm silvopastoral systems such as cattle, buffalo, sheep, and goats have the potential to provide greater economic, societal, and environmental value. We argue that oil palm-livestock integration is a practice that can drive the palm oil industry in a sustainable direction. In addition, we recommend that certification bodies (e.g., RSPO and MSPO) recognize oil palm-livestock integration (via targeted grazing) as an environmentally-friendly weed management practice. Widespread adoption of oil palm-livestock integration has the potential to positively impact agricultural productivity, and build ecological resiliency and economic prosperity. Nonetheless, more extensive research is required to quantify the effects of oil palm-livestock integration in benefiting crop yields through weed control at an industrial-scale. Targeted grazing at present, provides oil palm growers a viable alternative to chemical treatment to control weeds in industrial plantations.

CONCLUSIONS

The palm oil industry would achieve multiple SDGs by implementing oil palm-livestock integration or silvopastoral practice. Out of the 17 SDGs, oil palm-livestock integration is likely to deliver nine SDGs. Palm oil certification bodies should acknowledge oil palm-livestock integration as a low carbon footprint and biological control method in weed management practices that are compatible with the existing certification standards. We propose that oil palm-livestock integration should be promoted to strengthen sustainable palm oil production and strategic biodiversity conservation policy in all major oil palm producing countries. Policy makers in those producing countries should incentivize major players in the palm oil industry to seriously consider oil palm-livestock integration as an environmentally and socially sound production strategy.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

BA, KT, AS, and RZ: initially conceptualized this study. BA, KT, FN, MS, ZI, NR, AO, AS, and TM: helped improve the manuscript. All authors contributed to the article and approved the submitted version.

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