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Analysis of the foreign direct investment, oil palm expansion, and food security in Indonesia: Sumatra and Kalimantan case studies

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Abstract
The continuing oil palm expansion on food security has prompted fierce debate. On one side, analysts argue that local community incorporation in the oil palm sector can increase food purchasing in the market. However, the expansion has also brought unprecedented consequences of losing highly nutritious food due to forest conversions. This study aims to analyze oil palm expansion and local food security in various regions in Indonesia by tackling the following questions: (a) Which factors influence palm oil expansion, and does foreign investment play a role? (b) How does palm oil expansion affect food security in Indonesia? Socioeconomic methods have been applied in this study, including a systematic literature review and qualitative interviews with key stakeholders from various domestic and international organizations. These two methods help us triangulate the academic literature findings with real-world situations as perceived by the actors in the related field. Results indicate that, firstly, foreign investors have not only made a direct investment to facilitate oil palm expansion, but also indirect financial intermediaries are held without holding financial equities to upstream oil palm companies (e.g., supply chain financing contracts, channeling using local financial institutions such as credit union). Secondly, while large corporations asserted monoculture oil palm expansions, some smallholding farmers use mixed cropland expansion to share food and oil palm crops in their own smallholding terms. With the oil palm expansion, farmers can secure a cash flow from palm oil, but an unintended outcome is less nutrition diversification, and often because of the distance to markets, some commodities are favored over a more diverse diet. The outcomes of oil palm development vary and are multifold, as some stakeholders report that some studies show improving cash flows at the farm level, but other studies insist that food insecurity still prevails.

1 Introduction

Oil palm plantation has been the main agricultural export and source of economic development for Indonesian economy. Amidst the positive contribution, many other opponents refute the positive effect and portrait the negative effects, especially on local livelihoods. For instance, food and beverage manufacturing relies on the oil palm as the source of their raw materials [1]. Even, the oil palm business association (GAPKI) asserts the important local economic development from oil palm economy. Nonetheless, the opposition tends to perceive environmental degradation and reverse economic livelihoods from local oil palm expansion [2]. Another critic highlights the worse outcome of oil palm expansion to smaller land availability for the food cultivation [3].

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The public debates reveal the public uncertainty and complexity regarding the impact of the foreign direct investment, oil palm expansion and food security. With that extent public debates, the academic paper contributes to the extant literature by revealing a variety of impacts of FDI, oil palm expansion, and food security links. To gather relevant information, this paper combined the systematic literature review of different oil palm field studies and in-depth interviews related to oil palm development in Indonesia. The Google Scholar search engine exemplified about 330 thousand studies that discuss the link between oil palm expansion and livelihoods. Nonetheless, with specific criteria, we settled to correlate those relationships in Sumatra or Kalimantan; we found about 50 literature reviews. Those studies address either Sumatra or Kalimantan.

In this stance, how FDI in agriculture improves the food security situation of countries is a topic still under investigation, and studies in different parts of the world have yielded inconclusive results. The empirical evidence on the direct link between agricultural FDI and food security is quite limited, mainly due to the lack of disaggregated sectoral data [4]. Some studies show a positive relationship between FDI and food security because of the increased agricultural production and the possibility of employment, which increases household incomes [5, 6]. Other studies have found a negative link between FDI investments in agriculture and food security because of land use change and negative environmental and demographic impacts [7, 8]. Furthermore, with a meta-analysis of 24 primary studies of FDI on food security, Samdrup et al. find no conclusive evidence on a positive or negative link between FDI and food security. They do affirm that FDI is a contributor to economic growth, through technological spillovers and enhanced productivity, but that the performance of FDI depends on country-specific conditions [9].

To link the impact of FDI, oil palm expansion and food security, this study uses sustainable livelihood framework. The sustainable livelihood framework is utilized to examine the impact of changing human assets such as natural capital, social capital, physical capital, and human capital on food security [10]. The study uses SLA to measure the impact of oil palm expansion on changing human assets and food security. The structure of this paper consists of the sustainable livelihood framework, result, discussion, and conclusion.

2 The sustainable livelihood framework

Sustainable livelihood analysis has been applied in various agrarian studies due to its powerful assessment to include the environment and human capital. In our assessment, the extent of the local community adaptation on oil palm expansion was determined by their changing livelihood assets and strategies. When evaluating the oil palm expansion in Indonesia, the agrarian change is driven by proximate and contextual triggers. The proximate factors include the potential of resource conditions *vis a vis* the land availability in the upstream oil palm production [11]. On the other hand, the contextual trigger is driven by the external intervention [11], leading to the transformation of economic structures and institutional processes [10]. Some of those literature identified that the external intervention is sourced from the government policies as well as pervasive market speculation [10, 12].

The appropriateness of using SLF as the people to attain food security is determined by their strategy to accumulate their livelihood assets. In SLF, the changing livelihood assets (natural capital, physical capital, financial capital, human capital, and social capital) can lead to changing livelihood strategies [13]. Consequently, the situation leads to different livelihood outcomes regarding income, well-being, and food security [10]. The consecutive framework is drawn as in Fig. 1.

This paper investigates the livelihood impact pathway using the SLA Framework as in Fig. 1. It is important to note that this study has its own limitations in that it does not cover all livelihood outcomes, as our literature comparison does not draw on all the data. The focused outcomes, from our corroborating literature and panel expert interview, concentrate on access to food security. In the food security study [14], the inability to diversify livelihood assets is prone to malnutrition. Another study also landmarks the nutritional insecurity of the marginalized stakeholders who cannot apply the agrarian change effectively into their livelihoods [15].

In Southeast Asia, previous study asserts that oil palm investment has led to some complex agrarian transformation [16]. For instance, the oil palm provides new monetary sources for the local households living in resource-rich regions [16]. However, to another extent, economic transformation changes social relations of some subsistence producers, which in some instances weaken their customary bond [17]. With the conflicting system of modern economic arrangements, inevitably, some local communities operate to accumulate wealth at the expense of the poorest who face losing their previous natural assets. Hence, with the diverse capabilities of the local community to correspond with that impact, some studies assert unequal livelihood outcomes [16, 18].

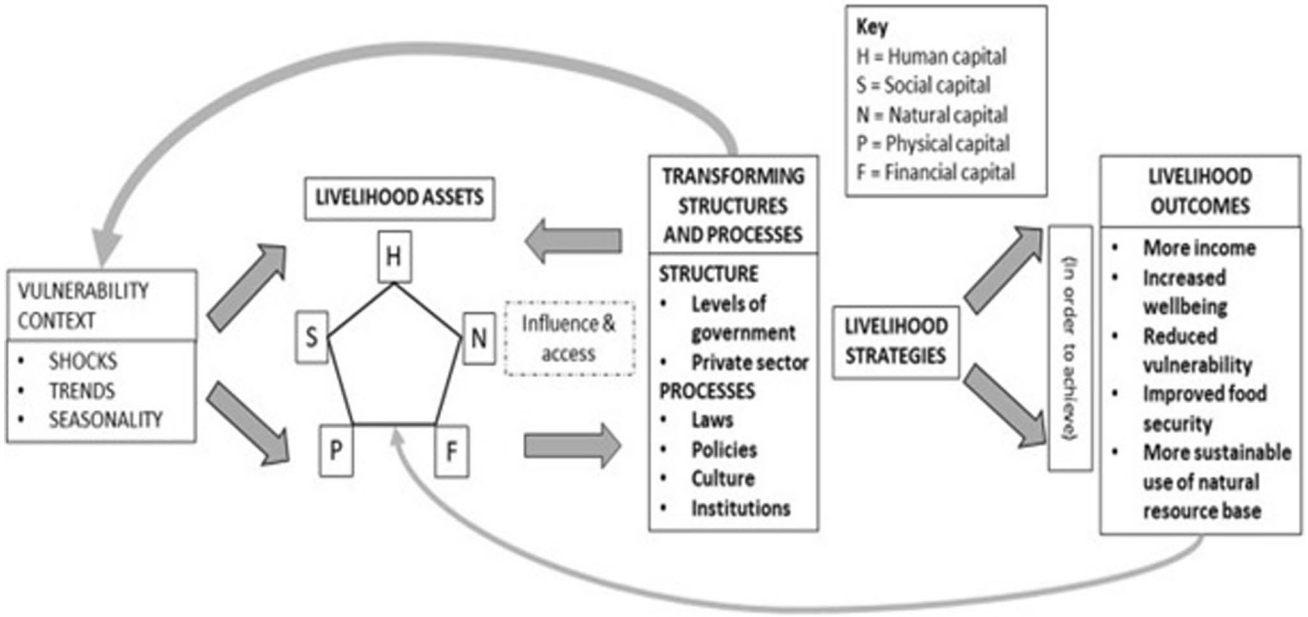

Fig. 1 Sustainable Livelihood Framework. [10] Source: Natarajan et al.

To explain the complex agrarian transformation, this paper measures the impact of global investment on the changing economic structures and institutional processes by comparing different case studies to understand the local contexts [19]. It measures the regional impacts of the changing economic structures and institutional changes in Sumatra and Kalimantan. Furthermore, when measuring changing rural assets, some measures are stressed. In credential, this study compares the changing natural capital associated with natural resource stocks (such as land and water) and other environmental services in the Sumatra and Kalimantan regions. When discussing physical capital, measures can be devoted to the physical infrastructure, housing, tools, and equipment [20]. Human capital measures can include knowledge, education, good health, and physical capability [10]. Social capital measures the changing social networks, social claims, relations, affiliations, and associations. The observation of financial capital expands wages, cash reserves, savings, and access to credit [21].

In the systematic literature review, there has been a varying finding related on access on nutritious food and well-being. Some studies exposed the oil palm outcomes in terms of monetary income and well-being [22, 23]. Other studies find that the market changes local access from more original nutritious foods to processed foods [12, 15]. With that diversification, this study attempted to expose variability of access on food and well-being in the Sumatra and Kalimantan islands.

3 The methods

This study combines the systematic review on the findings published in English-mode peer-reviewed studies and interviews with some key experts. The publications are selected based on several criteria, such as:

- The study was empirical, involving a field-based methodology in oil palm-producing regions in Sumatra and Kalimantan.
- The manuscript highlights one of the five livelihood capitals (but does not necessarily apply the sustainable livelihoods framework).
- The research exposed empirical evidence of oil palm in Sumatra and Kalimantan, rather than a theoretical or general discussion.
- The study considered the impacts on or demonstrates relevance toward smallholders in the local contexts of Sumatra and Kalimantan.

This study collects Kalimantan and Sumatra case studies for some fundamental academic reasons. In the past studies, before local palm oil was established, some forested communities relied on self-subsistence production in Eastern Sumatra and Western Kalimantan [24, 25]. While some others combined cash crop trading and some mining works, those non-swidden communities were exchanging the food in return for other non-food products to non-swidden communities [24, 25]. The selection of these islands was justified as there have been significant and event largest conversion of some secondary forests to oil palm plantation in total for Sumatra and Kalimantan in Indonesia from 1960 to 2015 [26]. Secondly, this study found that the largest field studies of our literature review scattering in Sumatra and Kalimantan Island. Those two reasons are the cornerstone to compare oil palm expansion in Sumatra and Kalimantan.

This systematic review investigates the title, abstract, and keywords of each article and was initially assessed, with a total of 50 articles satisfying these criteria. Our studies revealed that, regarding the oil palm field investment, the resonant keywords to consider were diverse financial strategy, global value chain engagement, and different investment forms. In deliberating the changing livelihoods, the keywords often appear as changing financial access, social networks, education, labors, infrastructures, savings, access to credit, off-farm and on-farm livelihood strategies, real monetary income, compensation, and nutritious issues as in Table 1. From the systematic literature studies, we found that positive sentiments across livelihood components are much fewer than those with negative sentiments. We acknowledged that, since our studies specifically measure sustainable livelihood frameworks, less than 15% of the literature review addresses all sustainable livelihood components, as in Table 1 below.

In addition to the systematic review, we conducted semi-structuring interviews with some key stakeholders. The semi-structured interview provides explorative information to validate the literature and to seek new information avenues [27, 28]. The semi-structured interview is more flexible in terms of providing open-ended topics that can modify the interview questions for selected respondents. In selecting the respondents, the key stakeholders are expected to avail comprehensive information on FDI, oil palm, and food security nexus. Some criteria were determined to select key respondents:

- The respondents had been involved in oil palm operation and its decision making.
- The respondents understood the debates of oil palm plantation in Indonesia.
- The respondents at least had some field experience to observe oil palm in Sumatra or Kalimantan.
- The respondents held upper-management positions and were involved in decision-making processes in relations to the oil palm activities.
- The respondents had some field experience regarding oil palm activities.

Table 1 Result of systematic review of field studies of Indonesian palm oil development

Number of studies	Livelihood components	Common keywords	(%) sentiments
27	Transforming investment structure in Sumatra and Kalimantan	Foreign investment, value chains, Agrarian transformation	Negative: 56% Positive: 15% Neutral: 19% Not Addressing: 11%
46	Changing livelihood assets	Education, labors, infrastructures, savings, access to credit	Negative: 52% Positive: 20% Neutral: 13% Not Addressing: 15%
44	Livelihood strategies	Off-farm, on-farm, livelihood, strategies	Negative: 48% Positive: 11% Neutral: 5% Not Addressing: 36%
45	Well-being (e.g., food security)	Diversified incomes, agrarian trajectories, nutrition, food access	Negative: 60% Positive: 18% Neutral: 18% Not Addressing: 4%

This study found 4 key stakeholders who fulfil the criteria. The selected respondents were coming from both national and international background, as in Table 2. Meanwhile, as for the activities, all our respondents consist of organizations that coming from both private and public sectors. Table 2 describes key respondents' characteristics:

The interview took between 40 to 60 min, with semi-structured interview topics as follows:

- Organizational perception towards oil palm expansion in Indonesia
- The impact of oil palm expansion on local livelihood, environment, and social life
- The perception of spatial planning policies for oil palm development in Indonesia
- Concern about national and international certification in Indonesia
- The perspective of the impact of oil palm on food security (food access, nutrition)

To minimize respondent bias in interview, the researchers revealed that the purpose of the interview is not for policymaking formulation but was for the academic purposes of the academic manuscript [29]. Moreover, the researchers emphasized that interview participation was voluntary, hence the respondents were comfortable revealing information. Some respondents from non-government organizations tended to reveal the negative impacts on natural capitals from oil palm development. On the other hand, national certified body respondent (Respondent 3) tended to advocate more oil palm production to induce a better rural economic outcome. Respondent 1 itself lends proportionate negative and positive oil palm impacts, yet the emphasis was on private sector compliant aspects when they were RSPO-certified oil palm companies.

4 Result

4.1 FDI in oil palm

Regarding the foreign direct investment (FDI) on Indonesian oil palm development, this paper found two themes in oil palm case studies, such as: (1) the economic reason for FDI and (2) the trend of oil palm investment in Indonesia. For global investors, palm oil investment promises more prospectus and the inevitable return to other investment modes [30]. As one of the main producers of palm oil in the world, Indonesia automatically positions itself as a potential market for foreign [31]. Historically, the Indonesian government opened the sector to foreign investors in the early 1990s, along with attractive incentives [32]. This followed Indonesia's commitment to the structural reforms outlined by International Monetary Fund (IMF), which required the government to ease restrictions on foreign investment in the palm oil sector. This marked the entry point of Malaysian plantation companies into Indonesia.

According to the accessible data, FDI in primary sectors (agriculture, forestry, and fishery) in Indonesia has shown increasing trend in the last 5 years, as in Fig. 2.

Indeed, FDI in agriculture takes 3–7% of the total FDI realization between 2017 and 2019, and the largest share of the agriculture comes from the oil palm investment [33]. Historically, the positive trend has been shown by the area harvested with oil palm in Indonesia, which increased dramatically from around 70,000 ha in the 1960s to 1.6 million ha in 1997.

Expansion slowed down during the Asian Financial Crisis in 1997–1998, as many plantation companies faced financial difficulties [34]. Another wave of foreign investment then occurred as the government invited investors to take over failing Indonesian plantation companies. In 1998, the total land area increased to about 2.01 million ha [35], and in 2006, Indonesian plantations achieved their tipping point and Indonesia overtook Malaysia as the largest producer of palm oil [36–38].

The positive trend of investment in palm oil continued until 2018, as it recorded that, between [39] 2003 and 2018, FDI in the palm oil sector reached USD 13.9 billion [33]. Meanwhile, from 2000 to 2018, Indonesia received up to USD 17.84 billion FDI inflow into agriculture and forestry combined, which tells us that the palm oil sector has become the most attractive sector amongst others in the primary sector. Meanwhile, it is more likely that Kalimantan region becomes the leading receiver, as it shows that from 2006 to 2018, on average, total FDI inflow across sectors to Sumatra provinces was 18,702.25 billion rupiah, while FDI inflow to Kalimantan up to 33,356.61 billion rupiah (BPS Indonesia).

The largest foreign investors of oil palm plantations in Indonesia mostly came from its neighboring countries, such as Malaysia (15,8%) and Singapore (53,7%) in the period of 2015-March 2021 [40]. For example, in 2019, Kuala Lumpur Kepong Berhad and Genting Plantation from Malaysia have opened a new palm oil mill in Indonesia [41]. According to the news, Kuala Lumpur Kepong (KLK) proposed to acquire a 60% stake in PT Pinang Witmas Sejati, which owns a total of

Table 2 Lists of key respondents

Respondents	Institutional backgrounds	Related experience to oil palm development in Indonesia
Respondent 1	International organization involving on oil palm certification	The respondent has engaged in managing international-certified smallholder and corporation oil palm plantation
Respondent 2	Leading environmental consultation	The respondent has provided the environmental consultation related to the impact of conservation and development to for-profit and non-profit organizations in Indonesia
Respondent 3	National association focusing on oil palm sector	The respondent has served as liaison to foreign counterparts related to Indonesian oil palm business
Respondent 4	Indonesian NGO focusing on smallholding oil palm farmer empowerment	The respondent has field experience empowering oil palm smallholders in Sumatra Island, specifically Jambi

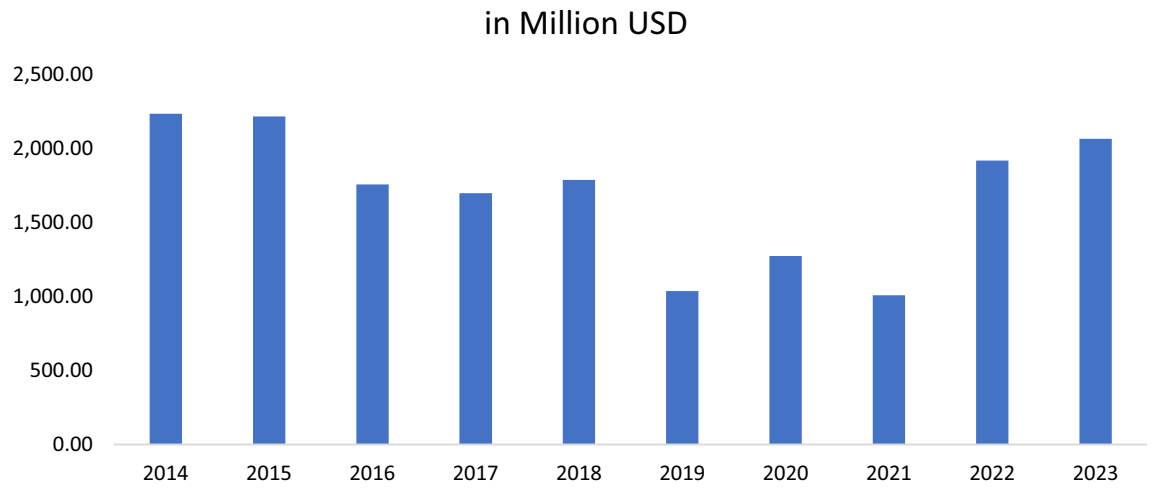

Fig. 2 FDI in Agriculture, Forestry and Fishery in Indonesia. Source: In Statista, Statistics Indonesia. (February 28, 2024) (https://www.statista.com/)

14,106 ha planted area and a 90 mt/h mill in South Sumatera, Indonesia, for RM 341.5 million [39]. Meanwhile, based on data in 2022, Singapore-based company, Wilmar International becomes one of the largest foreign investors in Indonesia by having 151.52 thousand ha planted areas of palm oil in Indonesia [42].

The positive trend of FDI inflow may influence the Indonesian palm oil sector productivity [43–45]. For example, the past study found that FDI plays a positive and significant role in increasing oil palm production in Indonesia, after other factors such as labor and land size [45]. Foreign companies enter the palm oil sector both by having direct investment (greenfield FDI) or via merger and acquisition mechanisms. In addition to the presence of foreign companies, the local regulation also increases the production of palm oil, as expressed by one of the respondents:

> *'There are a lot of ways for the foreign companies to invest in the Indonesian palm oil sector. First, maybe they invest directly by establishing the oil palm plantation. But for that, there is a requirement in Indonesian law that at least 20% of that investment has to be allocated for the smallholders… and then, the company also has to give them various technical assistance […].' (Respondent 4)*
>
> *'But there are other ways that the foreign direct investors invest in the oil palm sector is to buy the companies, through merger, through acquisition, something like that; but that comes later, not in the past.' (Respondent 4)*

Indeed, through the knowledge and technology spillover from the foreign companies, local farmers enjoy higher productivity that leads to higher income, which influences other locals to replace their current plantation into palm oil, as also revealed by our respondents (Respondent 4).

However, one should be aware that foreign investment can lead to social conflict that hinders food security. Indeed, the presence of different motives between the companies and local people or government becomes the reason for the conflict, as the former wants to extract profit rather than humanitarian reasons, whereas the latter wants to be part of economic activities that may develop their social conditions [46, 47]. Moreover, the entry mode of foreign investment, such as via merger and acquisitions, may lead to companies' different attitudes towards their commitment to the local people where the project is located [48]. One example was in Kalimantan, where the local people did not receive any profit or results from the agreement they had made with the company, even after the company had been transferred to another owner. This affected their food security conditions as they did not have any income.

4.2 Oil palm expansion and changing livelihood assets

Oil palm expansion in Indonesia has benign characteristics. For instance, many agricultural commodities were initiated based on the smallholding cultivation, such as coffee, cocoa, rubber, pepper, and the other similar commodities. However, since the oil palm applies capital-intensive farming and requires a lot of initial investment, the oil palm was firstly organized by the big-Agri firms in the outer Indonesian island. For instance, in early implementation in Sumatra, the state-owned enterprise facilitated PIR (Nucleus Scheme) in the 1980s to manage 30% of the land, while 70 percent were

managed by members of the local community [23]. Furthermore, the oil palm companies demanded management of more land shares. On the other hand, some studies underscored that oil palm development in Kalimantan was driven by the national government insecurity of economic threatening of Malaysia's occupation on that land by oil palm expansion near the border. With a lack of state resources to avail oil palm development, private investment was a sensible source to initiate in Kalimantan.

In the early 2000s, many oil palm plantations were established with more large-business controls to manage the oil palm fields. In this arrangement, the utilization of plasma land was shaped. In the system, the large-scale oil palm plantation managed all plantations, while providing 20 percent of the financial return to local farmers. This was then implemented in new oil palm development in Sumatra. Later, with more large-scale oil palm development, local farmers saw market opportunities to grow their oil palm in their backyards [49]. With the large-scale oil palm development, some farmers learned agricultural practices for oil palm and the market for their oil palm harvests. Therefore, this triggered land conversion.

4.2.1 Changing human capital

The influx of oil palm investment in Sumatra and Kalimantan has brought impacts on human capital. Human capital in this section refers to the knowledge, skills, and physical fitness that influence sustaining local livelihoods [50]. This study highlights the changing of human capital in these aspects: (1) education; (2) training, skills, and capacity building; and (3) health [49, 51–53].

Related to private investment in oil palm development, several government regulations (e.g., environmental impact assessment, infrastructure regulation) have obliged oil palm companies to provide sufficient formal education infrastructure surrounding their oil palm concession areas [54]. There has been improvement in the number of formal education activities, as reported in some Kalimantan and Sumatra case studies from the oil palm development [53, 55–59].

However, formal education access has uneven quality, and the local communities have different capabilities to access such formal education. In some field studies in Kalimantan, the quality of education among spatial sub-districts is different, in which one location can provide the minimum education service while the other performs below [60]. The inequality of essential education services also appeared in Sumatra oil palm contexts. While Sumatra has a better education literacy than Kalimantan, the uneven quality of teachers and facilities has appeared in different spatial geographies in Sumatra [61]. Moreover, Sumatra's education expenditure variability existed due to different monetary income sources received by different households in Sumatra's field studies [49, 62].

Furthermore, the establishment of large-scale oil palm development has brought some human capital investment. For instance, pressured by the buyers to avail standardized processing, some oil palm companies added corporate training and capacity building to their employees and the upstream producer partners. For instance, in Jambi, upstream oil producers have been pressured to avail a good, qualified harvest and comply with sustainable operation in their upstream producers by their downstream producers [63, 64]. The corporation that holds national and international certifications has set regulations to provide human safety, enhance productivity, and promote conservation practices surrounding oil palm corporations [65]. The monitoring and evaluation have been conducted periodically to ensure that access. Our interview with the key stakeholders related to international oil palm certification has strengthened farmers' good agricultural practices on RSPO's certified companies who owned concessions in Sumatra and Kalimantan.

> *'The benefit of being together [is] a collective benefit… get [farmer] capacity building, etc. And then the benefit of improving [their] good agricultural practices.' (Respondent 1).*

Nonetheless, some female groups have received uneven opportunities to participate to improve their human capital and skills. For instance, in North Sumatra's social culture, males dominate the social structures, and formal training can be eventually reaped mainly through male workers [66]. On the other hand, with heightening home chores and assistance to their children with schoolwork, some women could not access formal agricultural courses [66]. Specifically, in East Kalimantan's study, women were subject to greater workloads, such as spreading herbicide, plowing, and harvesting paddy and vegetables in the swidden fields [67]. This led to some women impediments to receive proper formal training to upgrade their human resources [68–70]. With that uneven capacity-building practice for females, they have been unfortunately responsible for more labor work on their families' independent smallholdings [66].

Another pertinent issue of human capital is health issues. For instance, in Sumatra's field studies, some farmers usually need to learn more about the technical requirements of palm oil and the lack of resources for effective

management [18, 71]. While some smallholders in Sumatra have pioneered fertilizer use in Kalimantan, they frequently apply inappropriate dosages of fertilizer. To some extent, these inappropriate chemical substances worsen their health [18]. In some Kalimantan studies, farmers even faced lower soil fertility due to the changing nature of the expanding corporate palm plantation [53]. Considering the low health awareness of such fertilizer and consumption of sugar carbohydrate foods, these oil palm agricultural practices negatively affect the local community's health [54, 56].

4.2.2 Changing social capital

In this study, social capital refers as the potential ability to obtain resources, favors, or information from one's personal connections [50]. Some field studies in Kalimantan and Sumatra revealed the common characteristics of social capital, comprising (1) producer's organization (2) labor relations, and (3) gender among the villagers. Labor relations here are specifically associated with social capital, as reciprocity and social relations are present and are driven by common purposes and values [72].

When discussing the producer's organization, the institutional arrangement is a key issue in Sumatra and Kalimantan agricultural activities. Institutional arrangement refers to the codifiable instincts, habits, and norms on local social relations that govern the collective resources [73]. In Aceh, prior to oil palm development, the local community relied on customary rules to share collective resources and to exercise sanctions upon those accruing more than was agreed. Reciprocal harvests were applied among family relatives to overcome scarce land [74]. In Jambi, customary leaders play a significant role in distributing land among households, and inequality issues were internally solved by familial negotiation [63, 75].

In the Kalimantan field case studies, prior to the oil palm plantation, customary leaders heavily regulated natural resource-dependent livelihoods. For instance, to some extent, subsistent food production was perceived as a necessary part of their culture to nourish the collectivity of an indigenous community in West Kalimantan [76, 77]. Those who owned rich landholdings inherited by their forefathers borrowed some of their land from those who received low land holdings to cultivate food crops [77, 78].

However, when confronted by oil palm development, the producer's organizations were more complex, and the households engaged in various institutions to support their livelihood activities. For instance, in some studies on oil palm development in Sumatra, local farmers now asked the local government institutions to assist with fertilizer and agricultural capacity building. They also engaged local cooperatives to reap the oil palm dividends in the engagement with a corporation [22, 23, 79]. They can even make informal engagements with migrants to sell their oil palm smallholdings [18]. Engagement with various market institutions weakened the customary role of organizing these smallholders. In Kalimantan, market mechanisms have replaced customary institutions to share agricultural inputs [60].

In the labor relations, more oil palm expansions were associated with the rigid labor structure and engagements [71, 80, 81]. In Sumatra, limited to monetary circulation and financial institutions, the labor reciprocal among households was exchanged with cash crops and food harvest (e.g., nutmeg, rice) [75, 82]. In some Kalimantan studies, with more rigid employment terms, greater monetary orientation brought a fragmented economic class, whereby richer ones exploited poorer laborers based on monetary resources that they had with a rigid contract and low payment in general [54]. For instance, with a market influence, reciprocal labor was exchanged through monetary compensation in Kapuas Hulu.

The impact of oil palm has had mixed results in improving women's livelihood; inequality is exacerbated in some cases, while others recorded improved participation among women [66]. In some studies, in Kalimantan and Sumatra, women had more time to allocate to home chores and oil palm labor [66, 83, 84]. As revealed by the following respondent, the meager return to work as oil palm laborers:

> *"The return on their labor is far too low compared to what they would normally make in high-value resources accepted from the forest and subsistence agriculture. So, for them, the economic calculation does not make sense." (Respondent 2).*

With very low return labor and higher responsibility, women are prone to labor exploitation in the Kalimantan setting. On the other hand, other studies indicated more improvement in women when oil palm farming came in Sumatra and Kalimantan [22, 79, 85]. An advocate of oil palm insisted that it can enhance farmers' income. For instance, our respondent reveals the following statement:

"For example, there are a lot of studies to show that the income of the oil palm farmers is better than the income of the non-oil palm farmers. So, when your income increases, your welfare improves, then I think they have more security in terms of their food, in terms of how they use their expenditures for education… (Respondent 3).

Some studies also insisted that women could have given more financial support to their husbands when the oil palm expanded due to more diversified jobs available for them [57, 86].

4.2.3 Changing physical capital

When discussing physical capital, the changing physical capital is related to supported physical infrastructures that can enhance household livelihoods [87]. In fact, changing physical infrastructure can reduce rural economic poverty in remote areas [88]. In this study, the expansion of physical capital is explained based on: (1) the infrastructure provision by the government, (2) oil palm companies, and (3) the local community.

In Sumatra, the national government had been very active in endorsing inter-regional infrastructure development to open more markets and trade on that island [89]. Amid greater infrastructure development, more oil palm can penetrate Sumatra and open the area to new economic activities to the local community [18]. The national government expand the fiscal budget for the local government to provide more electricity and health sanitation infrastructures to their local community [90]. This intervention is expected to avail more equal economic development among provinces in Sumatra [90].

In Kalimantan, government intention to expand infrastructure is related to maintain political economic sovereignty to Malaysia. In Kalimantan, some provinces were located near the Malaysian border [91]. To some extent, the national government was worried that the remote area of Kalimantan to Sarawak could weaken their political and economic sovereignty to the Malaysian government. Therefore, infrastructure and oil palm development were advocated to favor their economic existence and drive more market access to the local community [92]. Some studies revealed better electricity and road connectivity after oil palm farming expanded into the Kalimantan region [91, 93, 94].

Aside from the government, oil palm companies fulfilled their investor requirements and globally standardized certification to avail basic infrastructure such as health clinics, road connections within a village, and some schools surrounding their concessions [95]. Some studies in Kalimantan and Sumatra reported positive infrastructure development inside the oil companies' concessions [22, 96]. This infrastructure development extended the local community's access to purchase gas and harvests to distant villages to extend their economic opportunities [18].

Amidst the great infrastructure, there has been wide array gap of physical asset ownerships among households in Kalimantan and Sumatra. The common patterns are the increased consumption of luxurious products such as televisions and mobile phones also occurred among the richest in Sumatra contexts [18]. In Kalimantan, with road access, the local community can purchase affordable motorcycles in Malaysia and even in district capital cities [53]. In some cases, extensive market access drives more consumptive attitudes to purchase more physical assets such as television and mobile phones [56]. On the other hand, the poorest impoverished with a limited physical asset to endeavor some of their livelihoods in Sumatra and Kalimantan case studies [18, 62].

4.2.4 Changing natural capital

There has been great uncertainty in measuring the impact of oil palm development on natural resource changes in its impact on (1) forests, (2) water resources, and (3) biodiversity. Regarding the changing forest cover, environmental changes from oil palm expansion is difficult to measure [97]. Some macro-spatial studies in Indonesia, also covering Sumatra and Kalimantan, reported a loss of primary and secondary forests to oil palm plantations [98, 99]. In converse, some studies found a positive impact of oil palm trees to support the natural environment [100, 101]. For instance, the oil palm trees can revive previously degraded land and affecting existing of some biodiversity [102–105].

Some studies in Kalimantan and Sumatra stated that chemical use from oil has been debated related to the impact of water pollution from the oil palm expansion in Sumatra and Kalimantan [57, 106, 107]. Some of those studies indicated that the oil palm trees absorbed significant water under the soil, and their chemicals can pollute rivers, hence bringing hydrological pressure to the area with oil palm expansion [57, 106, 107]. Conversely, some proponents of oil palm development highlight that this development was operated in less environmentally degrading practices and, of course, will not have a significant effect on water resource pollution and pressure [108–110].

4.2.5 Changing financial capital

The oil palm expansion promotes more access to financial capital among rural communities. In Indonesia, the financial capital can come through financial insurance, savings, and credit for some communities surrounding the oil palm concession [111]. The following paragraph illuminates some studies of the oil palm development on financial access in Sumatra and Kalimantan.

In Sumatra, more oil palm investment boosts agricultural technology and extends more financial access to some of their local communities. For instance, in one case study, the firms' cooperative channeled the financial dividend and some credit assistance to some local farmers [112]. Other economic studies illuminate how the existence of the oil palm companies channeled income where some smallholders can save their money in the bank [22, 79]. However, other studies describe the wealth disparities between rich and poor households in the unequal financial access within Sumatra's field studies, respectively in Jambi [37] and North Sumatra [18].

In Kalimantan, with the slower pace of development of banking access, the alternative for financial access has been facilitated by the credit union [113]. For example, in one case site in Sanggau, West Kalimantan, the past ethnographic study describes how the smallholding farmers were able to borrow money with lenient requirements from the credit union for the oil palm plots [113]. In addition, a benefit to the credit union channels credit access for the oil palm farmers. With more oil palm, Central Kalimantan has had more financial access [114]. Indeed, credit unions provide some kind of education and health insurance for their members [115]. Nonetheless, other Kalimantan case studies showed of the unequal access between the wealthy and the poorer households in other Kalimantan studies [93, 116]. This unequal position led to the accumulation of poor labor to work for the oil palm plots of rich households [93].

4.3 The food security impact on Sumatra and Kalimantan

Our study uses sustainable livelihood analysis to explore the impact on the food security, as the instruments can map actors and interactions along the food value chain—including input supply and production of crops, livestock, fish, other agricultural commodities, transportation, processing, retailing, wholesaling, preparation of foods, consumption, and disposal [117]. This study highlights two outcomes as food security proxies, namely (1) well-being and (2) nutritional vulnerabilities, as these outcomes have been recently undertaken as the prime considerations in various food security studies. Well-being underscores human capabilities to suffice nutritious food [10].

Several oil palm studies illuminate agrarian paradox from the oil palm plantation in Indonesia. For instance, policy makers in Indonesia have sought FDI in agriculture as a mechanism to increase agricultural productivity, export revenues, and create jobs. Typically, FDI in agriculture is viewed as important for agricultural and economic development, especially through improvements in four areas: (a) creating more jobs, (b) providing access to markets and technology for local producers, (c) generating increased local and national tax revenues, and (d) improving social infrastructure, often through community development funds [4].

Nonetheless, the modernized agricultural development exacerbates the food insecurity complexity. For instance, the complexity of the food security situation in Indonesia is observed through some nutrition indicators, which show that 28% of Indonesia's children are underweight and 37% of children under 5 suffer from stunting, which is a worrisome statistic for a middle-income country like Indonesia [118]. On the other hand, the prevalence of overweight and obesity has steadily increased among children 6–12 years old, adolescents, and adults, plus evidence also suggests that micronutrient deficiencies prevail [119].

With oil palm development in Sumatra, some farmers have changed from net food producers into net food consumers. Some studies indicate that food vulnerability in Sumatra is driven from the unstable fluctuation of local food prices and shortages [15, 18, 49]. For instance, severe food vulnerability, as described by Qaim et al. [15] bring some household challenges to obtaining sufficient caloric consumption, dietary diversity, fruit, and vegetable consumption. The uneven household coping system to external environment, uncertain informal land ownership, and food price fluctuation led to severe nutritional food vulnerabilities of the poorest households [15]. Other studies also found that the poorest households are the most vulnerable population to external food shocks in Sumatra [103, 105, 120].

Furthermore, in Kalimantan, the poorest and the women are the stakeholders most prone to food insecurity. Some local communities relied heavily on natural resource economic activities to support their economic well-being prior to large-scale palm oil development. Some cultivated their food plots, maintaining their vegetable garden [67, 121, 122]. While waiting for the food and vegetable harvests, some of them planted cash crops such as rubber and pepper as a source of their cash income [24, 123]. With that nature, they sold the rubber and pepper when they needed it for urgent

demands, such as family health medication. With greater oil palm expansion, some households hold lower land assets, as some of their natural assets were transferred for large-scale oil palm development [124]. The emerging development of large-scale oil palm farming extended the connectivity of the Trans-Kalimantan Road infrastructure project [124].

The above systematic literature review describes both positive aspects to well adapted households who can organize their livelihood strategy to oil palm, yet it can leave the worse food insecurity to the poorest, as strengthen in our interview below:

> *"I think the cash is not related to the fact that they will get good nutrition, or they can get access to their food. But that does not necessarily mean that they improve their food security situation, because sometimes they want to spend the extra cash on other things, including motorbikes, for instance" (Respondent 4).*

5 Discussion

This discussion synthesizes the systematic literature review and interview results. In this paper, we found that foreign direct investment is a sound capital investment as it provides more certain return for investors. For instance, in the economic crisis, global investors were uncertain about investing in various financial and mortgage instruments subject to the magnitude of economic fluctuation and risks [125]. Investing more in agriculture increases the investor's land entitlements, and the fruit is a marketable cash crop with a more predictable investment return [126]. Among the different vegetable oils, palm oil has the cheapest processing production, and the raw material is mainly required for industrial food processing products [127].

The more complex changing livelihood assets are found when some households successfully accumulate more capable human resources and financial capabilities as their means to diversify their livelihoods and less dependable to natural resources. However, as reported in the results, the poorest households were impoverished to access the basic human capital and financial capital.

In fact, those complexes changing on livelihood asset the oil palm development brings divergent directions on the households' food security outcomes in Sumatra and Kalimantan. For instance, in Sumatra's case studies, several authors highlight uneven well-being and household nutritional vulnerabilities. For instance, in Jambi, the past study asserted the distribution of economic welfare as part of local citizens' well-being [15]. While transmigrants can have various agricultural technical access and adopt monoculture oil palm farming, the autochthonous communities cannot integrate oil palm farming well into their livelihoods. Some of the poorest transmigrant can suffer with food insecurity [37, 105]. Table 3 presents the summary of oil palm expansion in Sumatra and Kalimantan.

6 Conclusion

The study explores the factors that influence palm oil expansion, also considering the role of FDI in expanding oil palm expansion. Moreover, this paper explores the effect of oil palm expansion on food security in Indonesia. This paper also investigates the effect of oil palm expansion on food security in Indonesia. These issues are substantial to explore in the agrarian study, as there has been a shallow exploration that connects the effect of oil palm expansion on food security.

Table 3 The summary of impact of oil palm expansions in Sumatra and Kalimantan

Result	Sumatra	Kalimantan
Foreign direct investment	Mergers, acquisition, supply chain contracts	Mergers, acquisition, supply chain contracts
Changing livelihood assets	Improving some livelihood assets to those well adapted to oil palm, yet the market institutions tend to be overarching livelihood arrangements	Improving some livelihood assets, yet the customary institutions are weakened. The poorest has limited livelihood assets
Well-being and food security	Improving well-being and food access to some households who adapted well with oil palm economy. The poorest has a worsen well-being and food security	Some households were found to have better food and well-being. The poorest suffers the worsen food access to nutritious food

Many agrarian studies tend to concentrate on environmental considerations, while not extending the implication on food security issue.

The study finds that multinational corporations came into the oil palm expansion in Indonesia with different mechanisms (such as greenfield investments, mergers and acquisition, and other mechanisms) to inject funds into the oil palm expansion. The participation of households to oil palm expansion uses the combination of natural capital (e.g., land), physical capital (e.g., physical infrastructure), human capital (e.g., human resource), and social capital (e.g., social networks) in Sumatra and Kalimantan.

The oil palm expansion has a differential livelihood outcome among households in Sumatra and Kalimantan. The inequal livelihood outcomes brought consequences to the economic exploitation of the poorest households by the few richest households. Based on the systematic literature review and the panel expert interview, the well-adapted households acquire greater well-being and are less prone to malnutrition in Sumatra and Kalimantan. Nonetheless, the poorest groups are prone to worse well-being and are more vulnerable to malnutrition in Sumatra and Kalimantan.

The study has some limitations. Firstly, this study does not capture the field study by activities. There will be an uncovered field update regarding the effect of oil palm expansion on food security. Future study can provide a field studies comparison of oil palm development in different provinces or islands. Furthermore, the study does not compare oil palm review beyond Indonesia. Future study can perform more comparative studies that cover Indonesia and oil palm producing countries.

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Data availability The data that support the findings of this article are available upon email request from the corresponding author.

Declarations

Ethics approval and consent to participate The authors are committed to the ethical standards laid down in the 1964 Declaration of Helsinki. This study did not require ethical approval from any national, autonomous, or local Ethics Committees. This study consisted of interviews with key respondents and publicly available secondary information. Participants freely consented to participate in the interview with verbal consent.

Competing interests The authors declare no competing interests.

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